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User's Guide to WILBR Software for the Dec Alpha Workstation

STEPHANIE F. KOONEY

Ocean Acoustics Branch
Acoustics Division

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Stephanie F. Kooney

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A user's guide is presented for the WILBR software installed on a Digital Electronics Corporation ALPHA system. WILBR is an array performance and data quality assessment software program with the additional capability of characterizing the ambient noise field. This version of WILBR has been adapted from the VAX version used at SACLANTCEN, La Spezia, Italy to reside on the ALPHA system at Forschungsanstalt der Bundeswehr fuer Wasserschall- und Geophysik (FWG), Kiel, Germany. Other modifications for this version include a beamformer capability and slight modifications to the WILBR routines to accommodate the unique specifications of FWG's digital towed array (DTAS) data. The user's guide provides general information about WILBR on the ALPHA system and gives examples of the WILBR products available with this version. It explains how to install WILBR and provides step-by-step instructions on running the program. There is a quick locator for applying modifications to accommodate different array specifications, such as different filter functions, or new shading capability, or an updated data acquisition system.

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CONTENTS

INTRODUCTION TO THE USER'S GUIDE

WILBR is an array performance and data quality assessment software program with the additional capability of characterizing the ambient noise field. It is designed to reside on a VAX computer system. This version of WILBR has been adapted from the VAX version used at SACLANTCEN, La Spezia, Italy to reside on the ALPHA system at Forschungsanstalt der Bundeswehr fur Wasserschall- und Geophysik (FWG), Kiel, Germany. Other modifications for this version include a beamformer capability and slight modifications to the WILBR routines to accommodate the unique specifications of FWG's digital towed array (DTAS) data.

This document is written in sections to provide information about WILBR to the various types of users. Section I is aimed at providing an overview and general knowledge about WILBR on the ALPHA. It contains a brief introduction to WILBR, as well as descriptions and examples of WILBR products available with this version. Section II is directed to those who must download or program with WILBR on the ALPHA system. It provides a list of source code, as well as the compile and link commands. A brief description of the input and output files is also given. Section III is for the processor, the hands-on user. A list of preliminary information needed to respond to the prompts is given, followed by detailed explanations of the WILBR prompts. Finally, Section IV is provided as a quick locator for applying modifications to accommodate different array specifications, such as different filter functions, or new shading capability, or an updated data acquisition system.

1.0 SECTION I: GENERAL INFORMATION ABOUT WILBR FOR THE ALPHA

1.1 Background of WILBR for the Alpha

WILBR has been under development for over 18 years and has been successfully used with many data sets from towed arrays, as well as vertical arrays. WILBR is a valuable tool in assessing the performance of an array as well as determining the data quality.
WILBR is based on several statistics, which are presented in various analysis products. These statistics can alert the scientists to problems on the array, such as, bad hydrophones, beamformer faults, flow noise, mechanical or electronic noise, etc., and give clues to locating and to correcting the faults. Used during data acquisition, the data quality can be improved or ensured before returning to the laboratory, where it is often too late for a correction.

WILBR also contains the Wagstaff Iterative Technique (WIT), which uses the acquired data to characterize the ambient noise field. The left-right ambiguity of the towed array is removed when data is acquired along three or more headings 30 deg apart. The WIT algorithm removes the ambiguity as well as discriminates against local and transient sources. The results are products that are array independent noise field characterizations.
The following manual has been written as a guide for using the WILBR Array Performance and Data Quality software system on the ALPHA. This version has been modified to accommodate the filter function and array spacing of the four octaves of the digital towed array at FWG. This software can also be used for the analysis of vertical array data.

1.2 Capabilities of WILBR for the Alpha

The WILBR beamformer is a standalone beamformer, which processes LOGI formatted data and NORDIC formatted data and generates output files in the WILBR format (formats are described in Section II). Preliminary calibrations are performed in the WILBR beamformer. All other calibrations are performed in WILBR (see Section 2.3). The data can be processed with temporal Fast Fourier Transform (FFT) or Discrete Fourier Transform (DFT) sizes between 16 and 8192 points. The default number of beams is equivalent to the number of channels if the number of channels is a power of 2, otherwise the number of beams is the next highest power of 2. For example, for 58 channels, the default number of beams would be 64.

The beamformer is a general code, however the WILBR-ALPHA version specifically identifies limiting parameters. This WILBR version is hardcoded to process data from an array with 64 hydrophones and will form 64 beams at four analysis frequencies. It will average a maximum of 200 FFT points (samples). An FFT for an equally spaced array and a DFT for a variable spaced array are options in the WILBR routines. The standard shading function is the Hann function, although Hamming is also available.

1.3 Products of WILBR on the Alpha

WILBR calculates several statistics and displays them in various analysis products. The statistics are the basis of the array performance and data quality analysis, as well as the noise field analysis. The statistics commonly used in the analysis products are:

AVGPR. The power average. The sum of the power intensities divided by the number of samples, then converted to dB.

dBAVG. The dB average. This is simply the geometric mean of the given series.

MEDIAN. The 50 percentile of the data.

PRDIFF. The power difference envelope. The envelope consists of two curves; the top curve is AVGPR - MEDIAN, and the bottom curve is MEDIAN - dBAVG.

Percentiles. The 10, 25, 50, 75, and 90 percentiles of the data series.

STDEV. The standard deviation.

WIT. Wagstaff's Iterative Technique. An iterative process that discriminates against transients in the noise field and resolves the left-right ambiguities of the towed array. (See Ref. 1 for a detailed description.)

The following is a brief description and example of the products the WILBR software generates, in the order of their appearance. For a more detailed description of the resultant plots and their use in the data analysis see reference 2.

1.3.1 Hydrophone Noise Level Plot

The hydrophone noise level plot (Fig. 1) is a result of module 7 of WILBR (the VAX tape input). One hydrophone plot is given for each of the analysis frequencies as each leg of data is processed. The hydrophone plot displays the noise level across the array. The top curves are the 90 percentile, median, and the 10 percentile. The bottom two curves make up the PRDIFF envelope. The expected value of the PRDIFF envelope for well behaved data is 2 to 3 dB. The absolute dB levels of the hydrophones, can be obtained by adding the number of dB indicated below each plot. The hydrophone plot is used to identify errant hydrophones, as well as determine if the hydrophone data is contaminated by transients. Good behavior across the hydrophones appears as a nearly straight line.

1.3.2 Phase Plot

The phase plot (Fig. 2) displays the phase relationship across the hydrophones of the array. The top curves are the MEDIAN and the AVGPR, and the lower curve is the STDEV. The phase is calculated when a strong source (i.e., 20 dB or greater above the background noise) exists in the beams. Good phase across the hydrophones appears as a horizontal or slanted straight line.

1.3.3 Temporal Anisotropic Cumulative Distribution Function (TACDF)

The TACDF and the time history (Fig. 3) are plotted for a user selected beam and analysis frequency. Up to three beams can be chosen. Plots for each selected beam at all four analysis frequencies can be calculated. The left plot is the time history of a selected beam. The event number (also called sample number) contains 1/binwidth number of seconds; so that 1/binwidth times the number of samples gives the total amount of time in the data segment displayed in the plot. The

TACDF is a display of the cumulative distribution statistics of the time history for averaging window sizes of 1 to 10 samples. Along the y-axis is the window width and along the x-axis is the percentage level. The constant level contours on the plot correspond to dB levels in the time series. A horizontal slice across the TACDF at a given window width is the cumulative distribution function for that window width. The TACDF in Fig. 3 is for 75 Hz and is read as follows. Using a window size of 4 samples wide to average the beam time series, results in 25 percent of noise measured will be below 66 dB. For a larger window size, such as 8 samples, 25 percent of the noise measured will be below 69 dB. This plot is useful in examining the character of the time history on a given beam.

1.3.4 Beam Noise Level Plot

The beam noise level plot (Fig. 4) is a result of Stats (module 3). The beam noise plot displays the noise level versus beam number for each analysis frequency as each leg of data is processed. The top curves are the 90 percentile, the median, and the 10 percentile. The lower curves make up the PRDIFF envelope. The vertical dashed lines indicate the forward endfire (left) beam and the aft endfire (right) beam. The broadside beam is always beam #32. Inside the dashed lines is the acoustic domain, that is those beams receiving energy from the noise field. Outside the dashed lines is the virtual domain. The virtual domain consists of beams formed by the FFT at frequencies lower that the design frequency of the array. Virtual beams are used in determining the sidelobe suppression level and noise suppression level of the array, as well as incoherent and coherent contamination in the data.

1.3.5 Statistics Table

The statistics table (Fig. 5) is another result of Stats (module 3). It is an ASCII file called STATS.DAT, which is opened in the directory containing the WILBR executable. This file contains a beam noise statistics table and a rank correlation matrix (see Section 1.3.6) for each analysis frequency as each leg is processed. The table includes (from left to right): the beam number, heading relative to the array, true heading, true heading of the ambiguous beam, beam width, percentiles, dB average, power average, standard deviation, skew, kurtosis, number of observations, number of runs, ZMSSD, ZTAU, PRDIFF envelope. The values in the median, 10 percentile, 90 percentile, and PRDIFF columns are plotted in the beam noise plot (Section 1.3.4).

1.3.6 Spearman Rank Correlation Matrix

The Spearman Rank Correlation Matrix (Fig. 6) is a beam to beam correlation matrix. It is used mainly as a gray scale indicator of the amount of correlation existing between pairs of beams. The Spearman correlation coefficient is placed above the main diagonal. Below the main diagonal, an "X" is placed where the beam to beam correlation confidence level is greater than 99.73%, otherwise a blank is placed in the location. This gives a gray scale effect. The desired result is to have no correlation in the acoustic domain, that is all white for the real to real beam correlation, apart from some correlation along the main diagonal which results from the overlap of the beams. Used together with the beam noise level plot, it aids in determining sidelobe suppression levels, and coherent and incoherent contamination.

1.3.7 Azimuthal Anisotropic Cumulative Distribution Function (AACDF)

The AACDF (Fig. 7) is an output of Noise Calcs (module 4). The y-axis is the azimuthal beam width, and the x-axis is the percent of azimuth below a beam level L, where the levels L are the constant level curves on the plot. One AACDF is plotted for each analysis frequency. The "look" sector is user selectable. The AACDF is calculated using beams looking into a given sector for the polygon legs (number of sets). The sector is defined in Fig. 7 as a 120 degree sector centered at 90 deg relative to the array. Data only from beams within this sector are used for the AACDF. The

sector can be chosen to exclude the noise from the towship or to "look" into a desired direction. The AACDF is read, for example, as follows. Using a 2 deg beam width, the beam will "see" levels of 46 dB and lower over 15% of the azimuths, and levels of 54 dB and lower over 80% of the azimuths. Narrow spacing between the curves and a high variability in levels indicates that there are discrete noise sources in the area. Wide spacing between the curves and a low variability is an indicator that wind noise is a dominate contribution to the noise. This plot is used for noise field characterization, as well as noise model validation.

1.3.8 Horizontal Directionality

The horizontal directionality (also called a Noise Rose) (Fig. 8) is the result of Rose Plots (module 5). This is the product of the WIT algorithm. The WIT removes the left-right ambiguity of the towed array and discriminates against transients, such as nearby ships or the towship (see Ref. 2). This is accomplished by using the legs of data from the polygon maneuver. The horizontal directionality is an array independent statistic that characterizes the ambient noise distribution over 360 deg at the polygon site. The four analysis frequencies are presented on one page. Below each polar plot, the frequency, the omnidirectional level, and the standard deviation is given. The omnidirectional level is added to the level read from the plot for absolute values.

1.3.9 Array Heading Rose

The array heading rose, AHR, (Fig. 9) is based on the horizontal directionality and is a result of Rose Plots (module 5). The upper right hand plot is the horizontal directionality for a given frequency. The four plots below it are the array heading roses, one for each of four "look" directions (the gray shaded sectors). The angle and width of the "look" directions are selected by the program user. The array heading roses indicate the signal-to-noise (S/N) gain relative to broadside at 360 headings for a given look direction. Inside the zero circle are headings of degradation, and outside the zero circle are headings of improvement relative to broadside. On the zero circle are headings with S/N gain equivalent to using the broadside beam. From this information, the optimum heading can be selected. One page of plots is generated for each analysis frequency.

1.3.10 Percentile Plot.

The percentile plots (Fig. 10) are also a result of the WIT algorithm. The 10 percentile and 25 percentile horizontal directionalities are normalized to the omnidirectional level of the median and overlaid on the median horizontal directionality. The four analysis frequencies are presented on one page. The frequency, the omnidirectional level of the median level and the standard deviation of the median level are given below each plot. The omnidirectional level is added to the level obtained from the plot for absolute values.

1.3.11 Beam Noise Polar Plot

This beam noise plot (Fig. 11) is a polar representation of the noise levels in the acoustic domain of the beam noise level plot (see Section 1.3.4). The levels are normalized to the omnidirectional level given below each plot. The four analysis frequencies for a given leg are on one page. The arrows indicate the heading direction. To obtain absolute levels, add the omnidirectional level to the values plotted. The polar beam noise plots provide a view of the spatial variability relative to array heading. The plots are symmetric about the heading direction because of the inherent left-right ambiguity of the array.

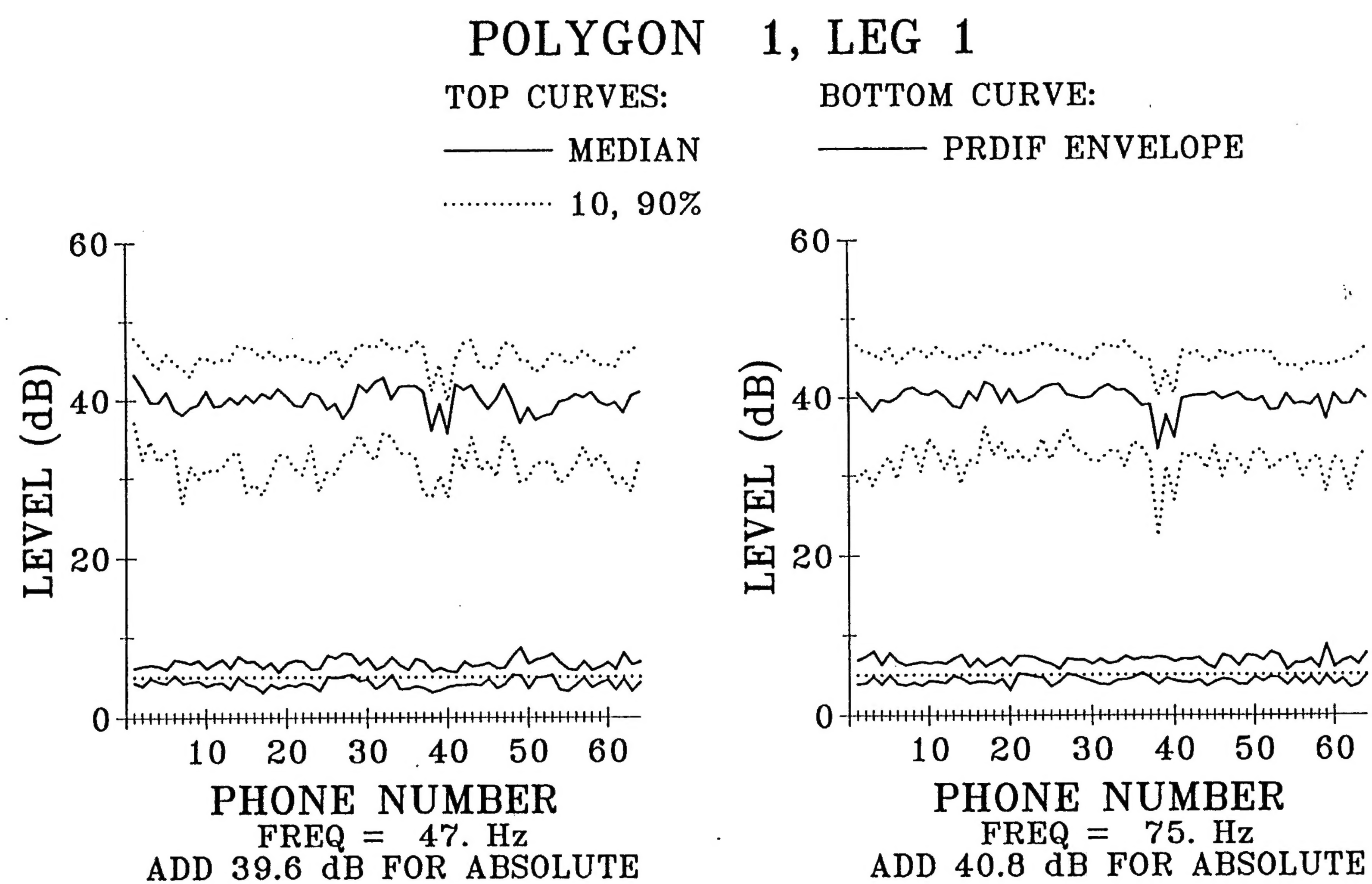


Fig. 1 – Example of a hydrophone noise level plot

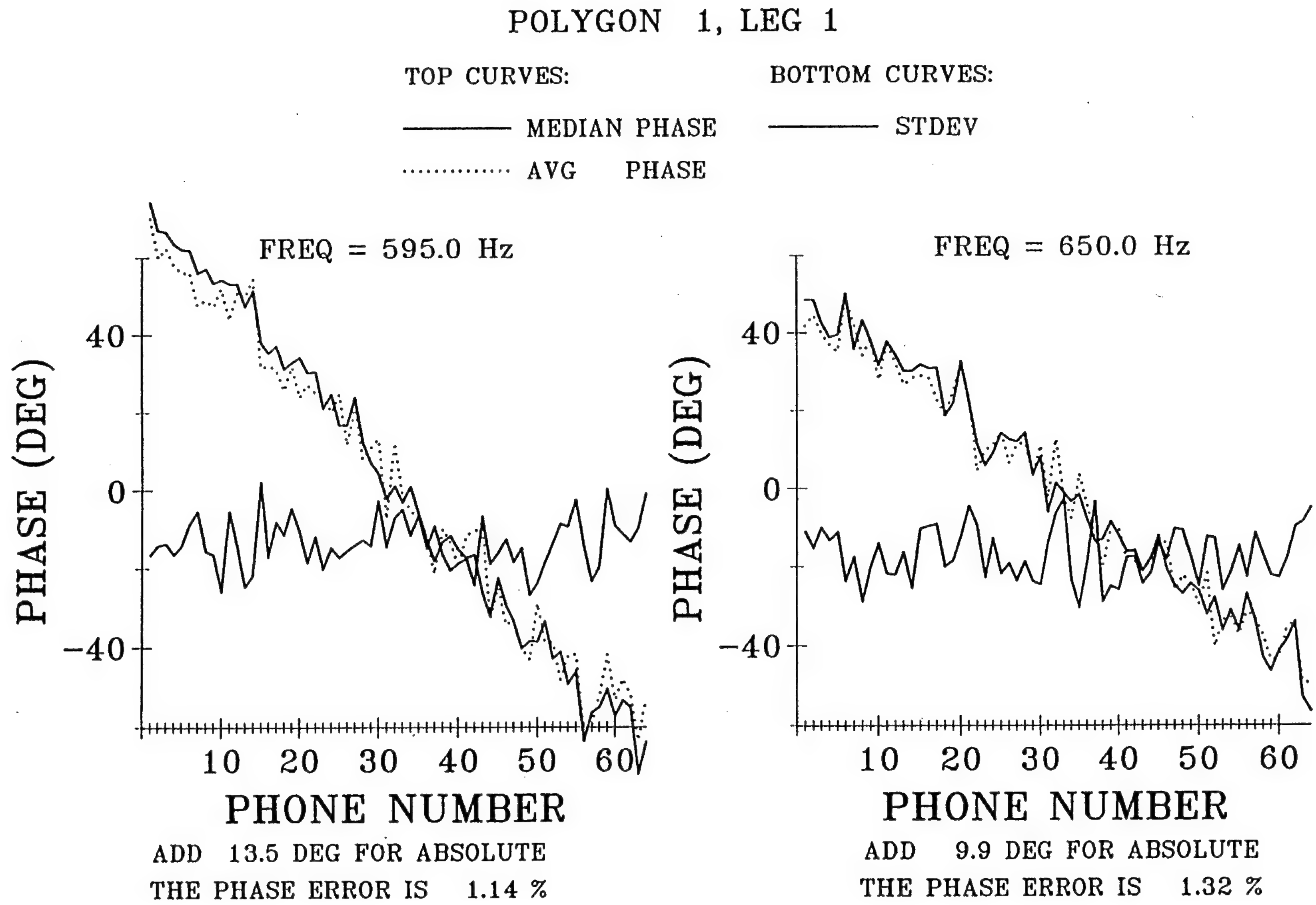
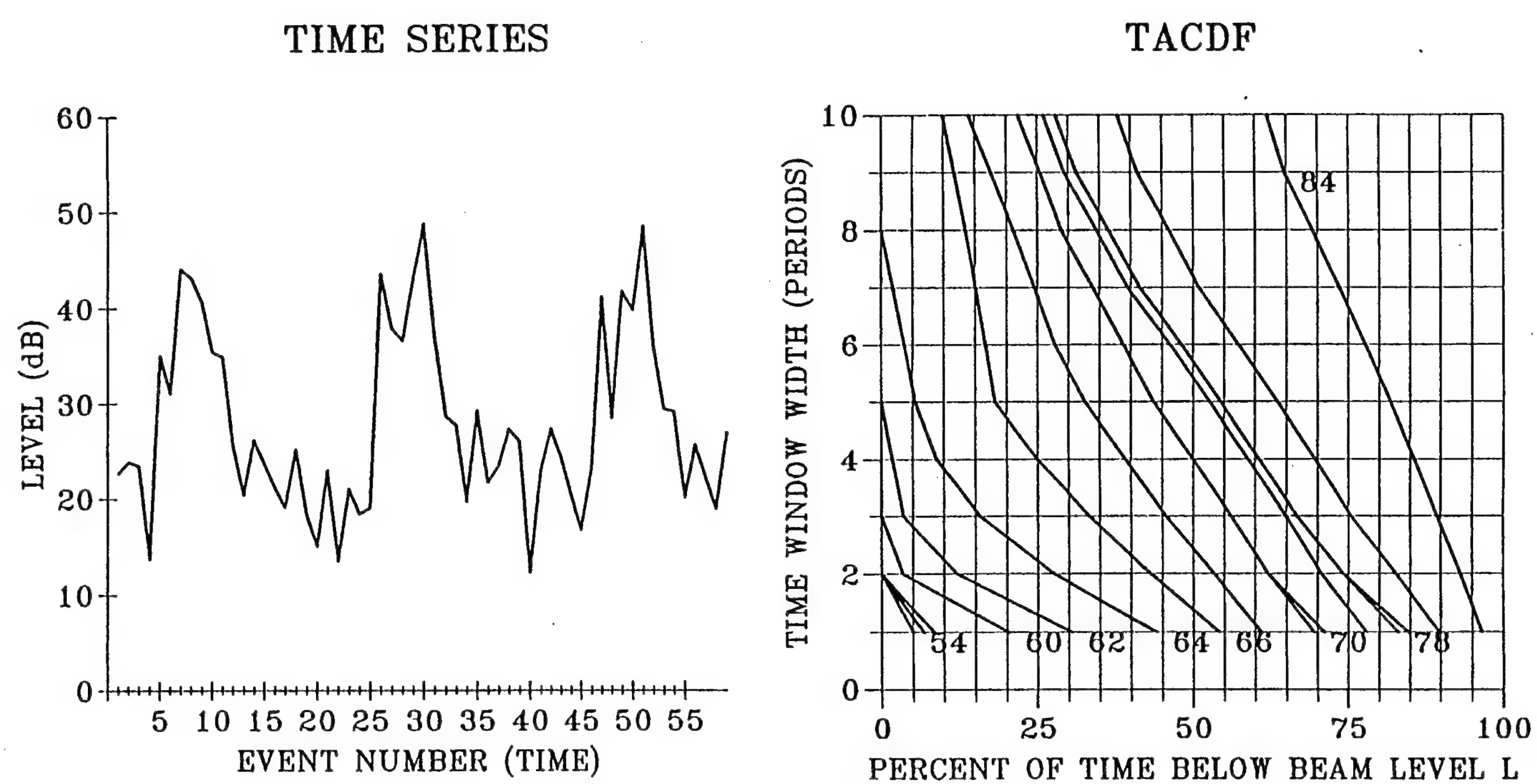


Fig. 2 – Example of a phase plot.

POLYGON 2, LEG 3, BEAM 33

FREQUENCY 100.HZ DATE 5/15/1995



ADD 40 dB FOR ABSOLUTE

Fig. 3 – Example of a Temporal Anisotropic Cumulative Distribution Function (TACDF)

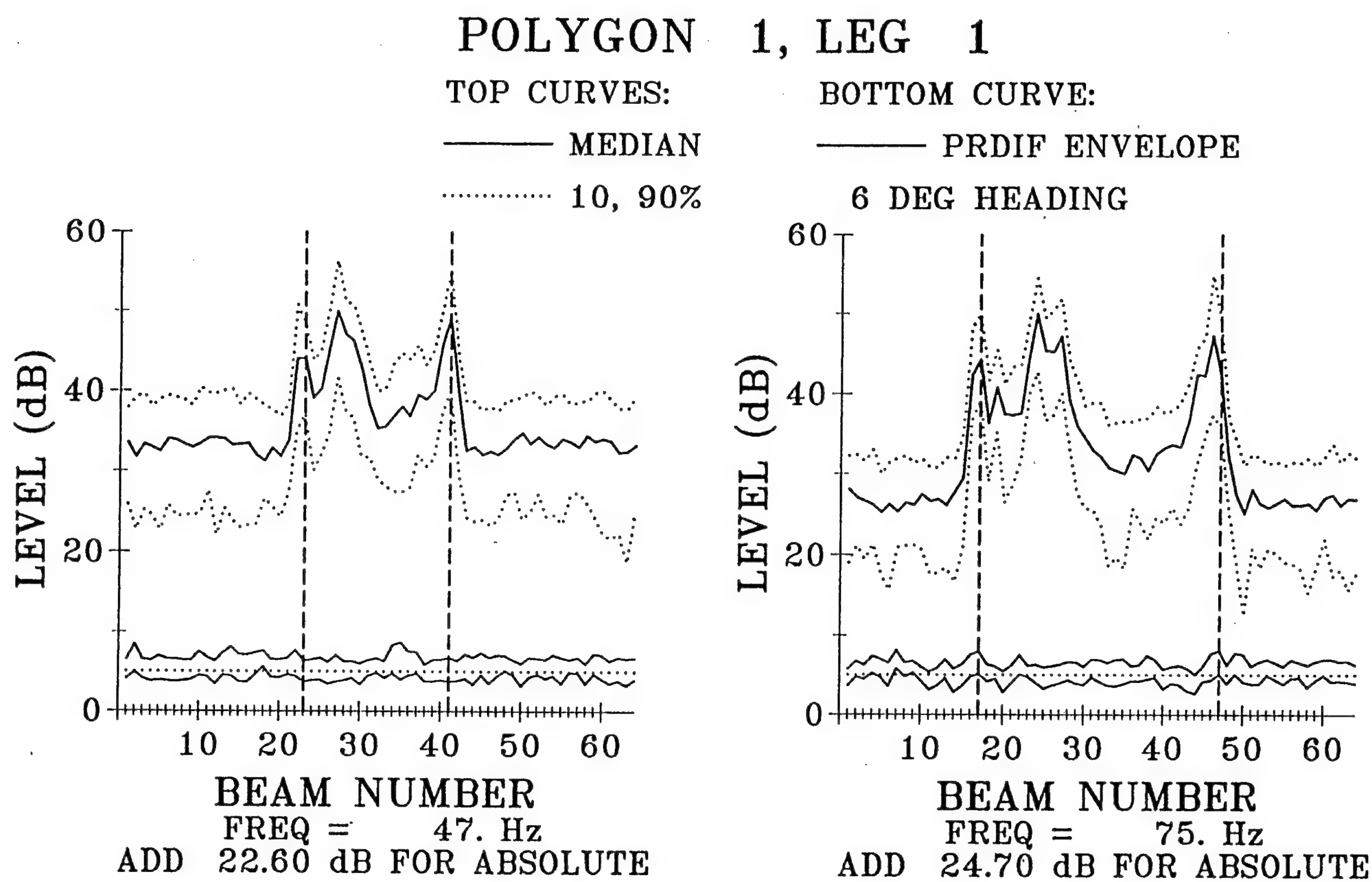


Fig. 4 – Example of a beam noise level plot

DATE 5/15/1995	SAMPLE SIZE 59			
TACTIC 2	LEG 3			
ST. TIME = 0 0: 0	HEADING = 336			
FREQUENCY = 75.0	GAIN = 114.0			
SOUND SPEED =1480.	SIDELOBE = 45.0			
LAT= 0 0.00 N	LONG= 0 0.00 W			
DEPTHS =	170	170	1000	0 0 M.

WEIGHT = HANN
ARRAY = LINE
# AVG = 1

BEAM	RHDG	THDG	THDG	BW	10%	25%	MEDIAN	75%	90%	AVG	AVGPR	STDEV	SKEW	KURT	OB	ZRUN	ZMSSD	ZTAU	PRDIF
1					45.4	49.7	53.4	56.6	60.3	53.3	57.0	6.0	-0.2	0.0	58	-0.3	-1.0	0.6	3.8
2					47.3	50.9	54.0	56.8	58.9	53.5	55.8	5.0	-0.7	0.9	58	-0.5	-0.5	0.8	2.3
3					45.1	47.5	53.2	56.6	58.7	52.2	55.1	5.6	-0.4	-0.6	57	-0.9	-1.6	0.2	2.9
4					43.5	51.4	54.9	58.1	60.8	54.1	58.0	6.6	-0.7	0.8	57	-0.1	-1.2	0.4	3.8
5					44.9	49.5	54.7	57.5	61.5	53.6	57.5	6.6	-0.7	1.4	57	-2.3	-1.3	-0.7	3.9
6					45.8	51.0	54.8	57.3	60.5	54.0	57.4	6.0	-0.5	0.5	58	-1.6	-2.2	-0.1	3.4
7					41.9	50.2	54.2	57.8	60.6	53.2	57.7	7.1	-0.7	0.6	57	-0.1	-2.2	1.0	4.4
.					.						.							.	
.					.						.							.	
.					.						.							.	
24					64.3	69.5	72.8	76.7	78.7	72.5	75.7	5.8	-0.5	-0.1	58	0.8	1.8	1.3	3.1
25	16.5	352.5	319.5	32.9	61.2	66.2	70.0	74.1	76.1	69.4	72.8	6.7	-1.2	2.2	57	-2.3	-0.9	1.7	3.4
26	35.5	11.5	300.5	19.6	64.1	67.8	71.8	74.1	76.3	70.7	73.2	5.5	-0.9	1.0	58	0.0	1.0	-0.4	2.4
27	47.7	23.7	288.3	15.2	60.5	69.3	73.5	75.8	78.5	71.8	75.5	6.9	-1.1	1.7	58	0.0	-0.7	-1.2	3.7
28	57.6	33.6	278.4	13.2	60.2	63.3	66.1	69.2	71.5	66.1	68.3	5.1	-0.9	1.1	57	-0.7	-0.9	2.3	2.3
29	66.3	42.3	269.7	12.2	56.7	62.5	65.7	69.0	72.9	65.7	68.8	6.3	-1.0	1.5	58	-0.5	0.0	-1.9	3.1
30	74.5	50.5	261.5	11.6	58.9	61.7	67.5	69.6	71.3	65.9	68.0	4.9	-0.6	-0.5	58	0.3	-0.1	-0.1	2.1
31	82.3	58.3	253.7	11.3	56.5	60.5	67.6	71.3	74.8	66.6	71.5	7.2	-0.2	-0.6	58	-0.3	0.2	-1.0	4.9
32	90.0	66.0	246.0	11.2	60.6	64.7	72.0	79.9	89.8	73.4	83.5	10.3	0.3	-0.9	57	-2.3	-3.3	0.2	10.1
33	97.7	73.7	238.3	11.3	65.1	72.9	78.7	84.1	90.2	78.0	87.4	10.6	-0.5	0.7	58	-2.9	-4.4	1.0	9.4
34	105.5	81.5	230.5	11.6	62.3	67.3	71.9	75.6	77.5	70.8	74.5	7.0	-1.0	1.1	58	-1.3	-2.8	-1.6	3.7
35	113.7	89.7	222.3	12.2	59.6	63.2	67.7	71.6	73.9	67.3	70.9	6.2	-0.6	0.7	57	-1.7	-0.7	-0.5	3.7
36	122.4	98.4	213.6	13.2	52.9	59.9	63.9	68.0	68.8	63.1	66.0	5.9	-0.7	-0.3	58	-0.3	0.7	2.0	2.9
37	132.3	108.3	203.7	15.2	53.7	59.4	62.4	65.4	67.3	61.9	64.1	5.1	-0.7	0.0	57	-0.1	-0.4	-0.1	2.2
38	144.5	120.5	191.5	19.6	56.7	59.4	64.5	68.1	69.8	64.0	66.6	5.4	-0.5	-0.4	58	-1.3	-0.8	-0.3	2.6
39	163.5	139.5	172.5	32.9	60.2	66.6	70.9	73.8	75.9	69.7	72.4	6.0	-1.0	0.3	58	-0.3	-0.7	1.0	2.7
40					64.2	67.6	73.5	75.4	78.7	72.0	74.9	5.9	-0.7	-0.2	57	0.4	-1.6	0.8	2.9
.					.						.							.	
.					.						.							.	
.					.						.							.	
62					46.3	50.0	53.5	55.9	59.4	53.3	56.3	5.6	-0.6	1.1	58	-1.1	-0.8	1.6	3.0
63					44.3	49.2	52.7	56.4	59.0	52.0	55.7	7.2	-1.6	4.7	57	0.1	0.1	-0.2	3.7
64					45.6	50.8	54.1	56.9	60.3	53.5	56.8	6.0	-0.7	1.1	58	-1.6	-2.3	0.6	3.3
65					81.1	82.2	84.8	87.0	92.9	85.7	89.1	4.6	1.2	0.8	58	-2.4	-3.1	-0.3	3.5
66					76.4	82.2	85.3	89.1	93.0	85.4	89.8	6.5	0.0	-0.3	57	-0.1	-1.1	-0.2	4.5

FOR BEAMS # 32 TO # 37 THE MEAN VALUE OF THE MEDIAN LEVELS IS 69.43 DB, THE STANDARD DEVIATION IS 6.03 DB
FOR ALL BEAMS THE DYNAMIC RANGE OF THE MEDIAN LEVELS IS 33.20 DB
THE OMNIDIRECTIONAL NOISE LEVEL ESTIMATED FROM THE MEDIAN LEVELS OF BEAMS # 32 TO # 37 IS 80.9 DB
THE NUMBER OF VIRTUAL BEAMS USED IS 49,THE VIRTUAL BEAM POWER LEVEL IS 58.71 DB.

BEAM 65 IS THE MEDIAN PHONE
BEAM 66 IS PHONE 31

PROCESSED ON 7/11/1995 1414:15
1

Fig. 5 – Example of a statistics table

```
                                          SPEARMAN RANK CORRELATION COEFFICIENTS'FREQUENCY    47.0
                                          STANDARD DEVIATION CONVERSION FACTOR = 0.0762
                                                      ARRAY = LINE
                                            LEG  4 OF POLYGON    2    5/15/95    0 0: 0
                                                    # SAMPLES =  59
 1         1         1         1         1         1         1         1
-733 243112 2 112222222 2     112  B    B 2  34133 31 233123  134 4
  73 113 3123312332    2  B B 1111111 1  2 1433331213331 241 14323
   73214123 3212142121212  B22 211BB  1     2322321122 323221 21
    75112422221  421 1111  B11           2  1 1   31  1  322 222 2 1
    X7313333211 12323  21  B 1BDC BC BB 11B3111212 3212  1 11 221
 X     73 121212 1112 121 BBB  1 B B  BC11 B32133 21 211  1  1332
   X    7 14133222432311  BBB     B 1  B B 1 4544313233222232113222
         7422 2  12221  1  1       11 1CC 13123113 31 1 23 1 11 21
    X    X734232 2331  21    B        1 B  12322323211 23231112321
       X  72231422323        1  BB2  1B D2 B4332334322231113122131
         X 73132212   1  B  1CB B      1  1 121213122  2123232222
              732225322  2 C 122  1 B 131 11 32343322322411432343 31
               73224311  1 BB  B 1  111     2 253321343221132311323
                7332212 11   B B11B          2115 2233411222 311 423
          X      74223221 2 1222 1 1112   11B4222343223522233325331
                 X7351331121  11 1    131B1 2 25123334333322454344 52
   XX  X     XX    75332222B    2111     11121 534242333225225434553 3
                  XX7343132 B122 1    1  B 13 43333244422422332544 33
                     722143C 212 1  B1 B  2BD3232312213223 22 2321
                    X 73 3331  311 2   CB  3 3312112223132122431 11
                       71561   31311 13  111B11 21 B 12 212344232
                        722B  1 131        2 C3  1 132 2123111  32 2
                     X X 76DB  2 2       B 3 D1 11    113 11 111122
                       X X7  124 3    B1 B211C       1 1 222 23122
                           75  231 1  1BB C    CBB 1 BBC 13 121BB
                           X7  21133 21B    11BB        121 2211  1
                             71 B 1 111    B B B 1 1  1      B1 11B
                              73 233   1 CB1     12111  132 212
                         X     72222 211  11 2   1        21 1 1211B1
                               743111 1  2   31 2  23 212111 112 B1
                               X76312 211    12 2   3 1 122111 31
                                X7421 21 2    B 1 1B111 1    1213
                                 X72212 B1         1 211213  1121BBB
                                   73B1  B     11 1   11B1  1212
                                    71     12 1  1    11B2 231121
                                     7 C1 1      11 22 11 12122  1B
                                      74B         1B   1    1 1  1
                                      X7 BB        BB  B      C   1
                                        7 11     1   BC BB   1  2
                                         7 D3 2 1 121323 C1    22 2
                                          73 11    112  121 131 13C
                                           7C1 B   B DB B      B  B
 X    X  X    X XX                          723432633334212211433 3
X     X     XX X                             73441431222 153113421
      X        X                               73322 122 B 32 1311
      X    X                                XX 7311113211142 26332
               X                             X  7411  221 3 124321
            X                                   X74332343123344  4
         X     X                            XX   X7522343221132243
           XX X X                                 X743243212224231
               X                                   X73232222322131
                                                     742313211412
            X                                        X72  32 24422
         X     XX                           X    XXX   74232443423
                                                       X7212322 21
 X       X   XX                              X X         74434421
             XX    X                                    XX7644241
             X    XX                                  X  XX75223
              XX                                  X    X    XX74121
- X      X XXXXX                              X  XXX X XX    XX X7533
X            XXX                               X        XX  X    X733
             X                                     XX        X     71
X                                                                  7
```

5.4 PERCENT OF BEAM COMBINATIONS CORRELATED WITH 99.73% CONFIDENCE

CORRELATION COEFFICIENT TIMES 10 IS ABOVE MAIN DIAGONAL
BEAMS WITH COEF OF GREATER THAN 99.73% CONFIDENCE MARKED WITH X BELOW DIA
1

Fig. 6 – Example of a Spearman rank correlation matrix

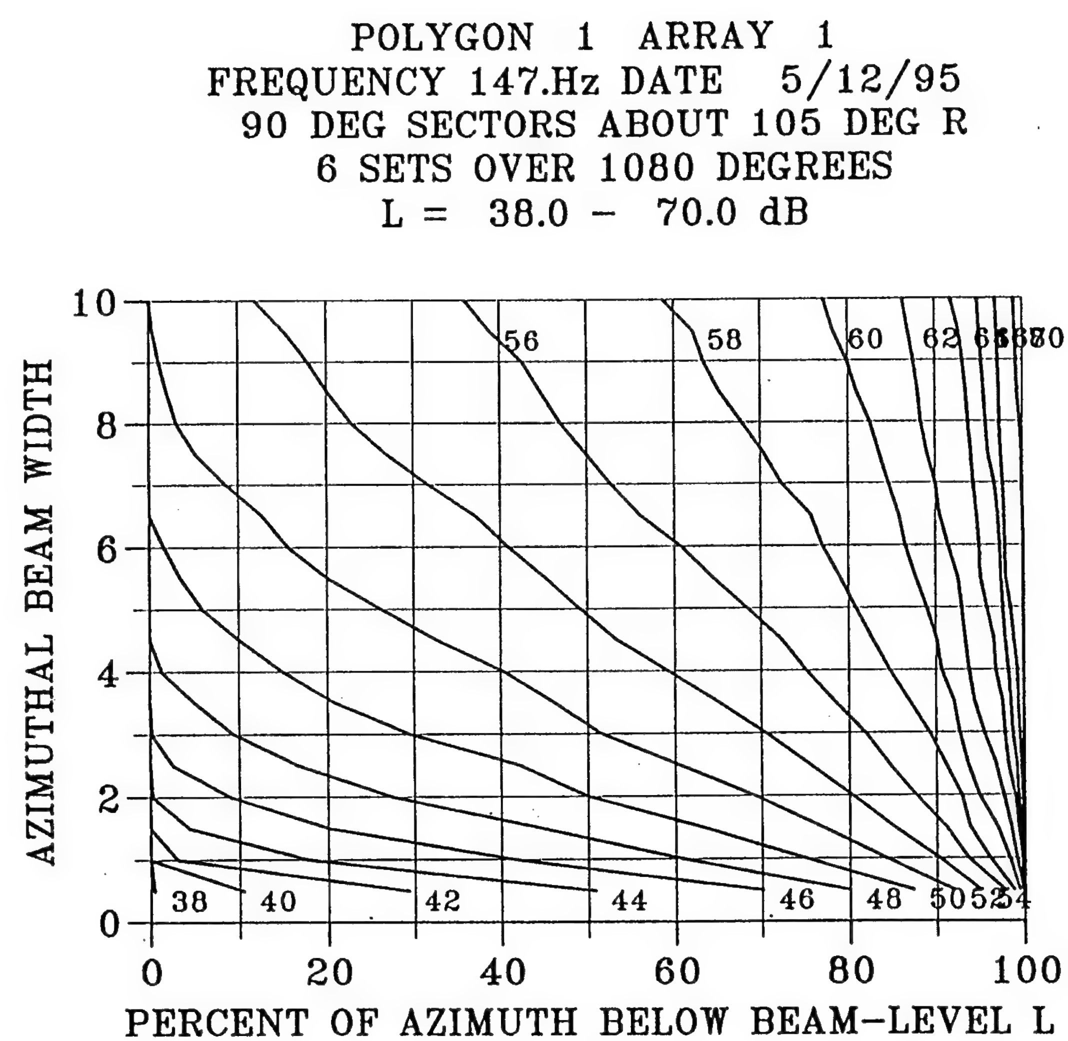


Fig. 7 – Example of an Azimuthal Anisotropic Cumulative Distribution Function (AACDF)

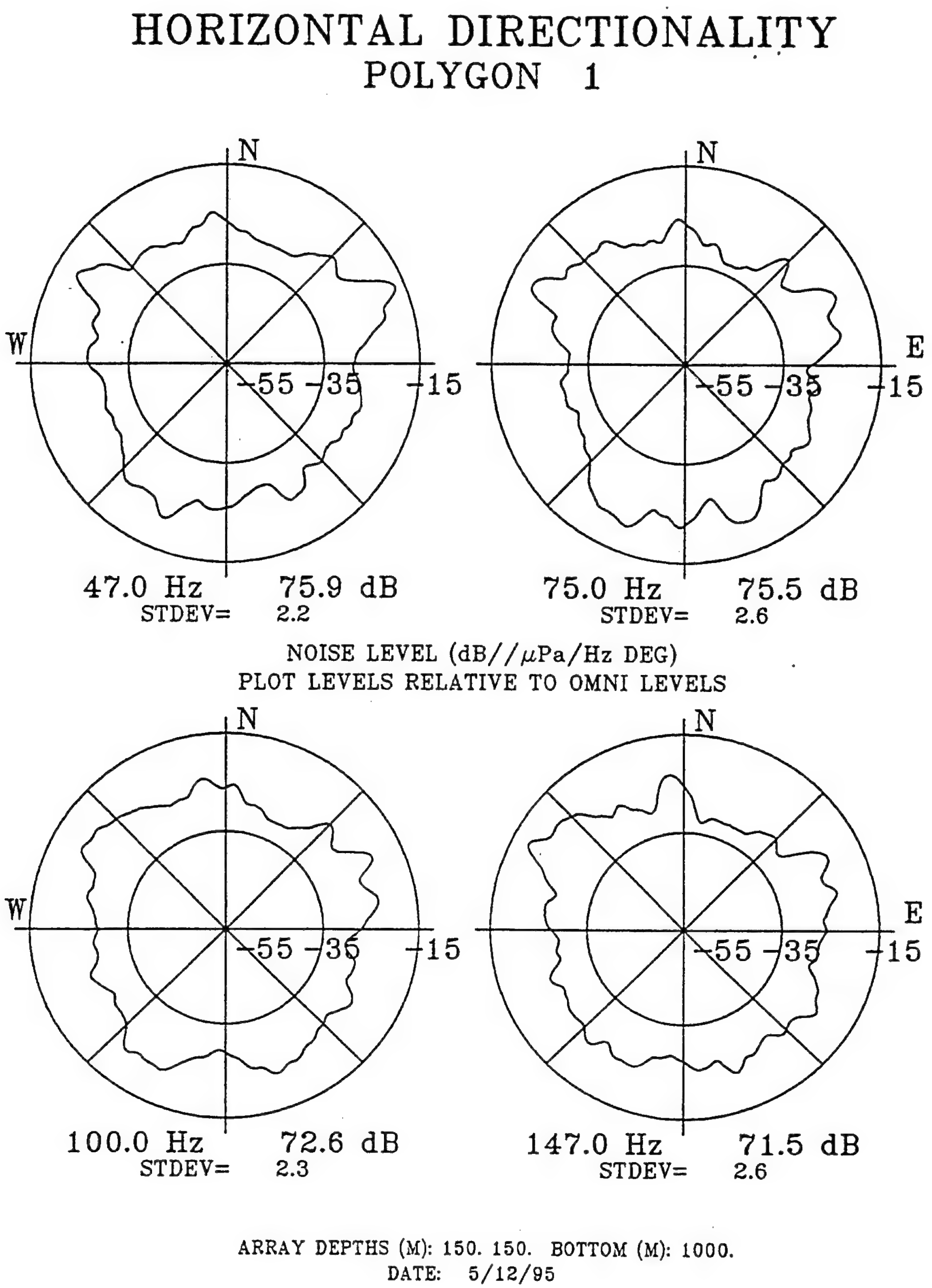


Fig. 8 – Example of a horizontal directionality plot

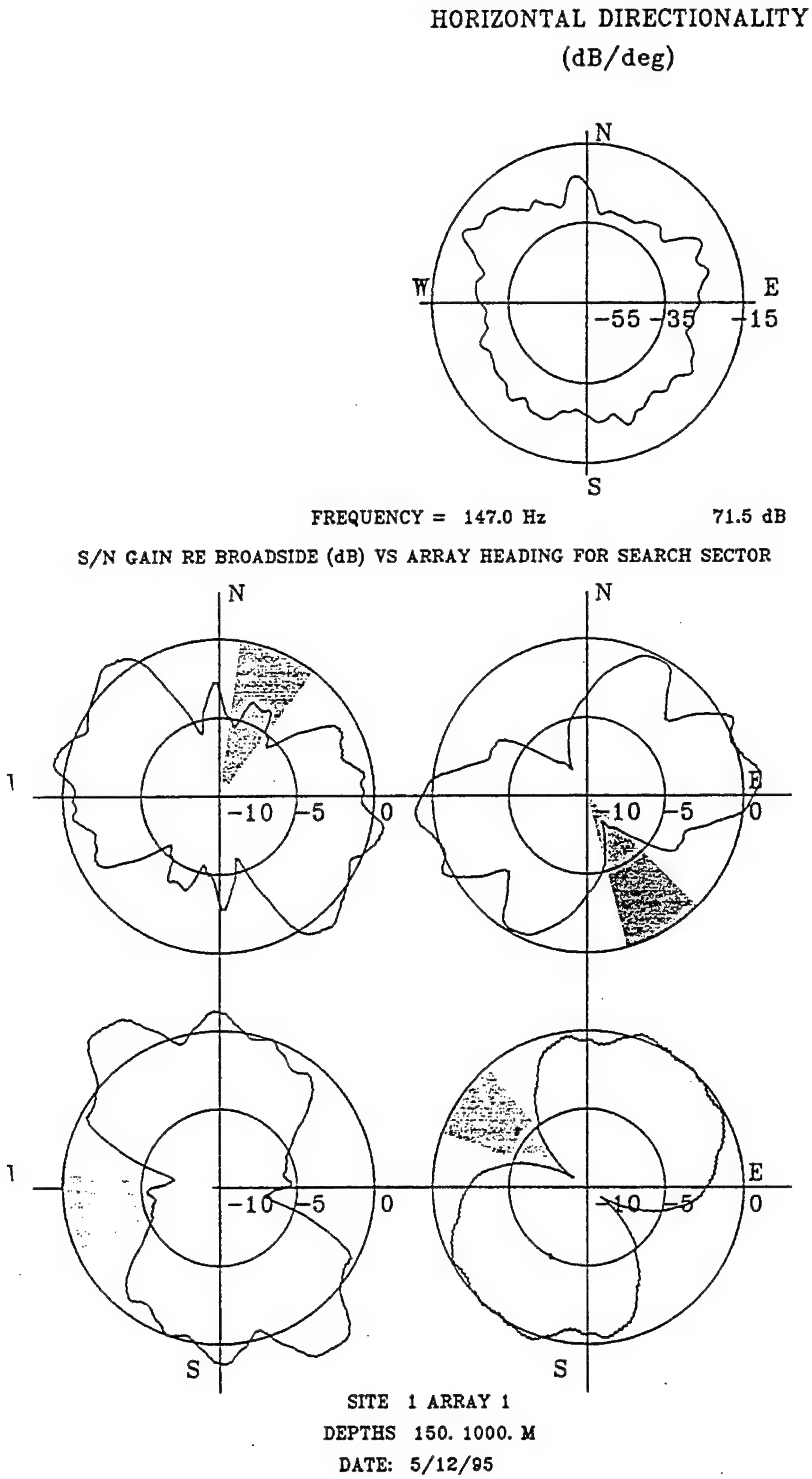


Fig. 9 – Example of an Array Heading Rose plot

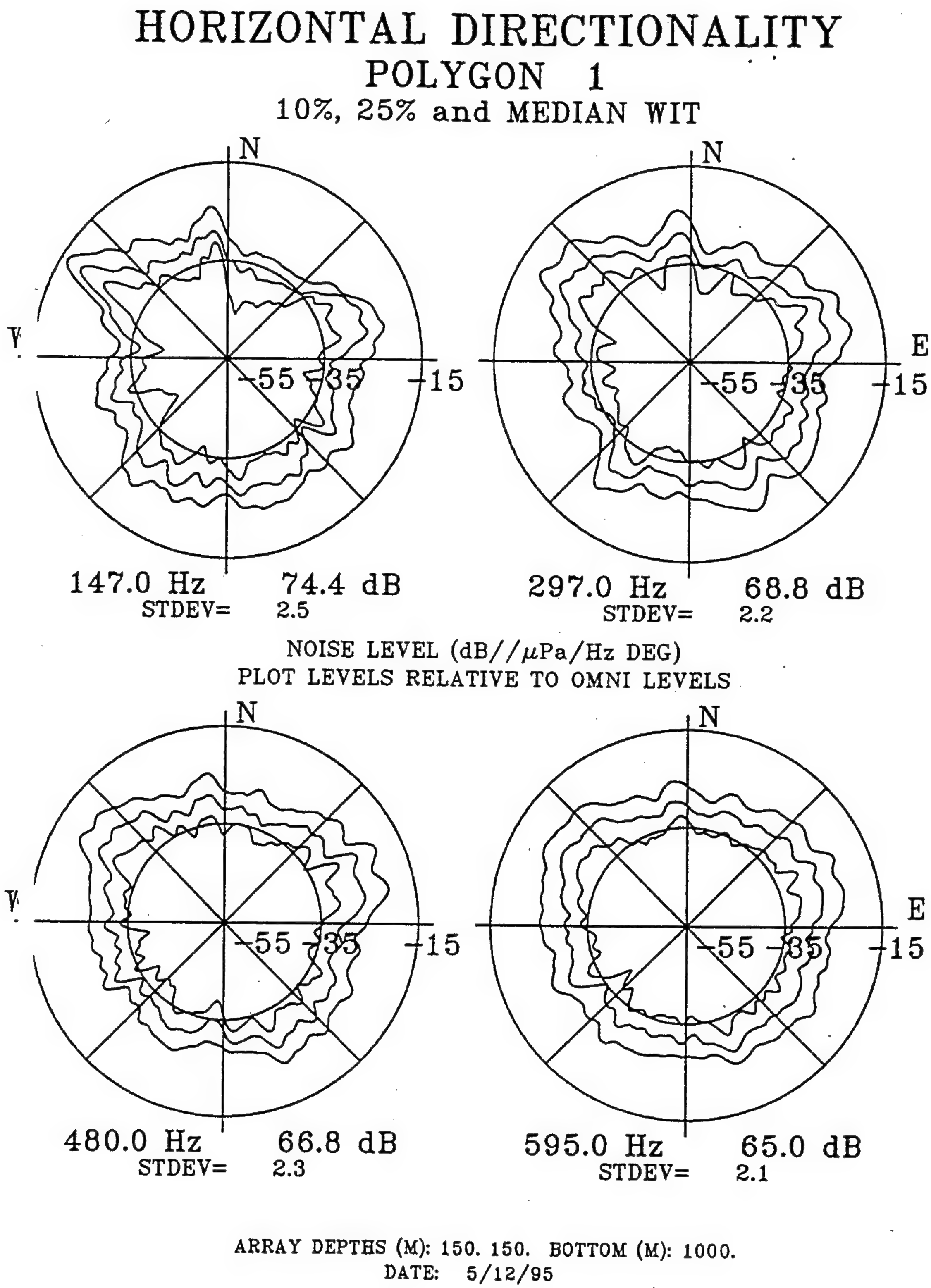


Fig. 10 – Example of a horizontal directionality percentile plot

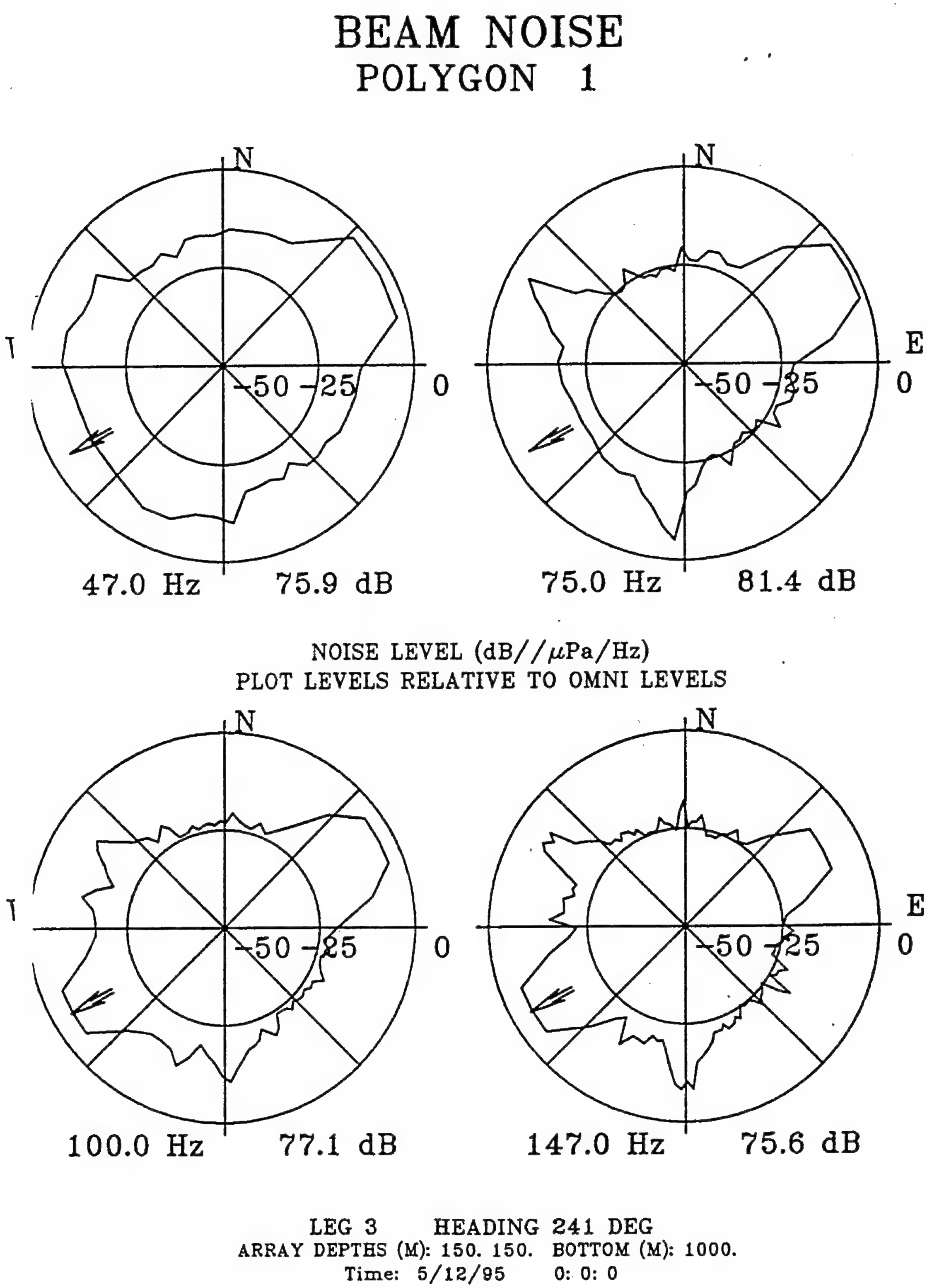


Fig. 11 – Example of a polar beam noise plot

2.0 SECTION II: FOR THE PROGRAMMER, SETTING UP WILBR

2.1 WILBR Beamformer (A Standalone Beamformer for WILBR)

The WILBR beamformer is called NEWBEAM. NEWBEAM performs a temporal FFT on raw data and spatially beamforms the results with minimal calibrations. The output file is formatted to be ready for use with the WILBR Towed Array Performance and Data Quality Assessment software. The following files are needed to generate an executable program: NEWBEAM.FOR, FT_BF.FOR, SPACING.FOR, LOGI.FOR, WATSUN_BEAMER.INC. Compile these with standard FORTRAN compile and link statements.

2.1.1 Input files to NEWBEAM

NEWBEAM reads uncalibrated data from a disk file in either NORDIC format or LOGI format. The NORDIC format (Fig. 12, left) consists of a header block, followed by raw data from 64 channels. The 16384 byte header block is in ASCII characters and contains the record size, number of channels, time stamp and sampling rate. For exact locations see the subroutine READ HEADER in NEWBEAM.FOR. The raw data is formatted as the first sample of data for 64 channels, second sample for 64 channels, third sample for 64 channels, etc. The file is sequential, unformatted, with a blocksize of 16384 and has a record length of 2048.

LOGI format (Fig. 12, right) contains no header block and is only data. The raw hydrophone data is formatted such that the total number of samples is recorded for the first channel, the total number of samples for the second channel, etc. This continues for all channels (see routine LOGI.FOR). The LOGI file is a sequential, unformatted file with a record length of 1024. The "header" information is contained in a separate file, of the form 'filename.PAR', where 'filename' is the same name as that of the raw data file. The PAR file contains the number of channels, channel assignments, sample rate, and start time. See the subroutine READ HEADER for the .PAR file format.

In addition to the input data file, NEWBEAM needs a template file (Fig. 13). If this file is not available, NEWBEAM creates one. The template file is in ASCII format and can be modified with any text editor to specify a given array. The template file contains the channel numbers, channel assignments, status of hydrophones, adjustable sensitivities, and location of channels. The status of the hydrophones is designated by a 0 for an unused hydrophone, 1 for a status of okay, -1 for a phase reversed hydrophone. The adjustable sensitivities are in dB and are used to adjust the sensitivity of an errant hydrophone. This would be the difference to be added or subtracted from the basic hydrophone sensitivity. The location of channels is in meters, where the first channel is 0.0 meters and the last channel defines the length of the array (i.e., the locations are cumulative). NEWBEAM has the options to create a template file for an equal or unequal spaced array. It is assumed that the array is FWG's DTAS and has 4 possible octave choices. An Octave 5 is available for an array of equal spacing but different from the DTAS. For another unequally spaced array, modifications must be made (see section V) to the software.

NEWBEAM creates an output file (Fig. 14) that is compatible with the WILBR software. The output file is a sequential file with fixed record type, unformatted, and a record length of 1024. It contains an ASCII header followed by the data in complex coefficient power values, to which the A/D factor and temporal and spatial shading have been applied. The header block has 256

characters, which contains the number of channels, sample frequency, number of segments, time between samples, number of acquisitions, number of frequency bands, time FFT size, temporal shading , starting frequency bin, number of bins to skip, number of bins in the frequency band, spatial FFT size, and spatial shading. Other frequency bands are available, but are not used. See routine VAX READ.FOR for exact format.

The main header is followed by a segment header, which consists of the segment number and the time. Then the first segment of data follows. Data is stored such that all frequencies are written for hydrophone one, all frequencies for hydrophone two, etc. until the total number of channels is reached. The hydrophone data is followed by the beamformed data, where data for all beams is written for frequency bin one, all beams for frequency bin two, etc. until the total number of beams is reached. The second data segment follows in the same manner: segment header, hydrophone data, then beamformed data. The third segment follows, etc., until the total number of processed segments is reached.

2.2 WILBR Software System on the ALPHA

For WILBR, the following files must reside in the same directory as the WILBR executable:

CDFT1.DAT	PLDAT.DAT
CASETUP.DAT	RDLMA.DAT
CDFST.DAT	PLSETUP.DAT
PLTST.DAT	TAU.DAT
NFSETUP.DAT	BANDS.DAT
NFCFG.DAT	SYSERR.DAT

Because input and output data files are usually large or many need to be created, it is suggested that a separate directory be maintained for WILBR data. To do this, create a directory for the WILBR input data and place CURRPROJ.REF and PHONE_AMP.DAT in this directory. Create a subdirectory called DATA in the input data directory. All WILBR output files (see Section 2.4) will automatically be placed in the directory DATA. These output files are used by the WILBR modules as input, output, and temporary files.

The following include files must be in the source code directory for compiling:

BMCOMM.DAT	PARAMETER.DAT
CALCSTRU.DAT	RDLMSTRU.DAT
FRES.COM	PLOTSTRU.DAT
NFSTRU.DAT	GLOBALS.FOR
MAINSTRU.DAT	

The following are the source code files of WILBR. See Appendix I for a list of subroutines within the source files.

AACDF_PLOT.FOR	HYPLT_SCLNT.FOR
FWG_SPACING.FOR	VAX_READ.FOR
STATS.FOR	DSI$ADD.FOR
ARYPF.FOR	NOISE.FOR
HARM_DFT.FOR	VAX_SAVE.FOR
TACDF_TIME.FOR	DSI$SELDEV.FOR
CDFPL.FOR	P2PLT_SCLNT.FOR
HPFUNC.FOR	WEIGT_DFT.FOR

TMCDF.FOR
CDFPL_SCLNT.FOR
HYDPHASE_SCLNT.FOR
VAX_OPTIONS.FOR
DATA.FOR
DUMMY.FOR
PLOTS_SCLNT.FOR
WEIGT_PS.FOR
FRES.FOR
SCLNT_VAX.FOR

To make an executable, compile the source code with FOR/NOWARNINGS filename. Compile PLOTS_SCLNT.FOR with FOR/NOOPTIMIZE/NOWARNINGS. Link the objects with UNISHR_LIB.

2.3 Calibrations

The calibrations are divided between the WILBR beamformer and WILBR processing routines. Preliminary calibrations take place in the beamformer. The beamformer uses the analog to digital conversion factor in volts/bit. The calibration equation in the beamformer is as follows:

SYSEN(i) = C_SENSTVY(i) + FILT_GAIN + DB_BIN
C_SENSTVY(i) = H_SENSTVY + LCCHN(i)

where SYSEN is the final sensitivity, C_SENSTVY is the channel sensitivity, DB_BIN is the binwidth correction, H_SENSTVY is the hydrophone sensitivity, and LCCHN is hydrophone sensitivity correction for a given channel. H_SENSTVY, FILT_GAIN, and DB BIN are hardcoded to 0.0 dB. LCCHN is adjusted in the template file with the system editor.

WILBR completes the calibration in the processing routines.
ICAL = KHSEN + IFLTR + ISCUG + IBWCR

where ICAL is the final calibration factor, which is subtracted from the data, KHSEN is the hydrophone sensitivity, IFLTR is from the filter function subroutine, ISCUG is the system gain, IBWCR is the binwidth correction factor.

For example, the calibration for the DTAS was as follows:

A/D = 0.0007071 , entered in the beamformer routine
KHSEN = -201 , entered in WILBR
SCU = 24.08 + gain setting + 60 , (60 dB is a constant from the filter function) result entered in WILBR
FILTR = result from the filter function in WILBR
IBWCR = is calculated in WILBR.

2.4 Output files of WILBR

The following files are created by the WILBR program and placed in the subdirectory .DATA. In the files listed below, "projname" is the project name selected at the beginning of the program, and "L#" is the number of the leg processed.

projname.FIT
projnameA.RES
projname.L#
projname.FTW
projnameO.L#
projname.LTW
projnameN.RES
projnameP.L#

projnameB.RES
projnameH.L#
projname.LIT
projnameC.RES
projname.RIT
projnameS.L#
projname.RTW

The main file is projname.L#, which is a file of the beam noise for leg L# after WILBR reads the output file of the beamformer.

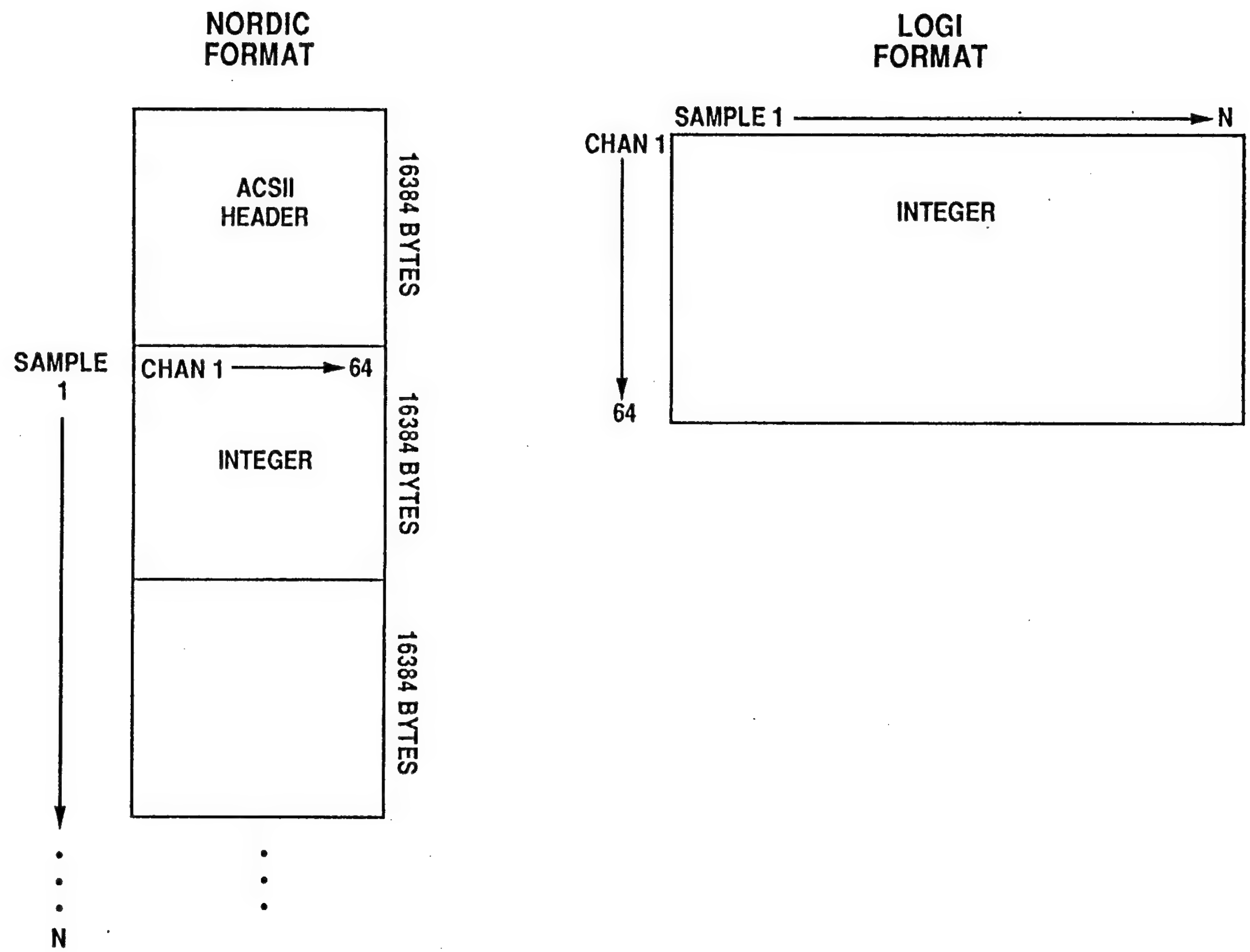


Fig. 12 – The Nordic file format (left) and the LOGI file format (right)

Template filename is:
watsun_beamer.dat
Edit this file to control the channel selection, etc.
Asgn = 0 if not used. Asgn = #, the contiguous order.
Stat = 0 null phone, Stat = 1 OK, Stat = -1 Ph. reversed

1	2	3	4	5	6	7	8	9	10	Chans
64	63	62	61	60	59	58	57	56	55	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
0	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	space
11	12	13	14	15	16	17	18	19	20	Chans
54	53	52	51	50	49	48	47	46	45	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
12.0	13.2	14.4	15.6	16.8	18.0	19.2	20.4	21.6	22.8	space
21	22	23	24	25	26	27	28	29	30	Chans
44	43	42	41	40	39	38	37	36	35	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
24.0	25.2	26.4	27.6	28.8	30.0	31.2	32.4	33.6	34.8	space
31	32	33	34	35	36	37	38	39	40	Chans
34	33	32	31	30	29	28	27	26	25	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
36.0	37.2	38.4	39.6	40.8	42.0	43.2	44.4	45.6	46.8	space
41	42	43	44	45	46	47	48	49	50	Chans
24	23	22	21	20	19	18	17	16	15	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
48.0	49.2	50.4	51.6	52.8	54.0	55.2	56.4	57.6	58.8	space
51	52	53	54	55	56	57	58	59	60	Chans
14	13	12	11	10	9	8	7	6	5	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
60.0	61.2	62.4	63.6	64.8	66.0	67.2	68.4	69.6	70.8	space
61	62	63	64	65	66	67	68	69	70	Chans
4	3	2	1	0	0	0	0	0	0	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
72.0	73.2	74.4	75.6	0	0	0	0	0	0	space
71	72	73	74	75	76	77	78	79	80	Chans.
0	0	0	0	0	0	0	0	0	0	Asign
1	1	1	1	1	1	1	1	1	1	Stats
0	0	0	0	0	0	0	0	0	0	dB Adj
0	0	0	0	0	0	0	0	0	0	space

Fig. 13 – Example of a template file used by NEWBEAM

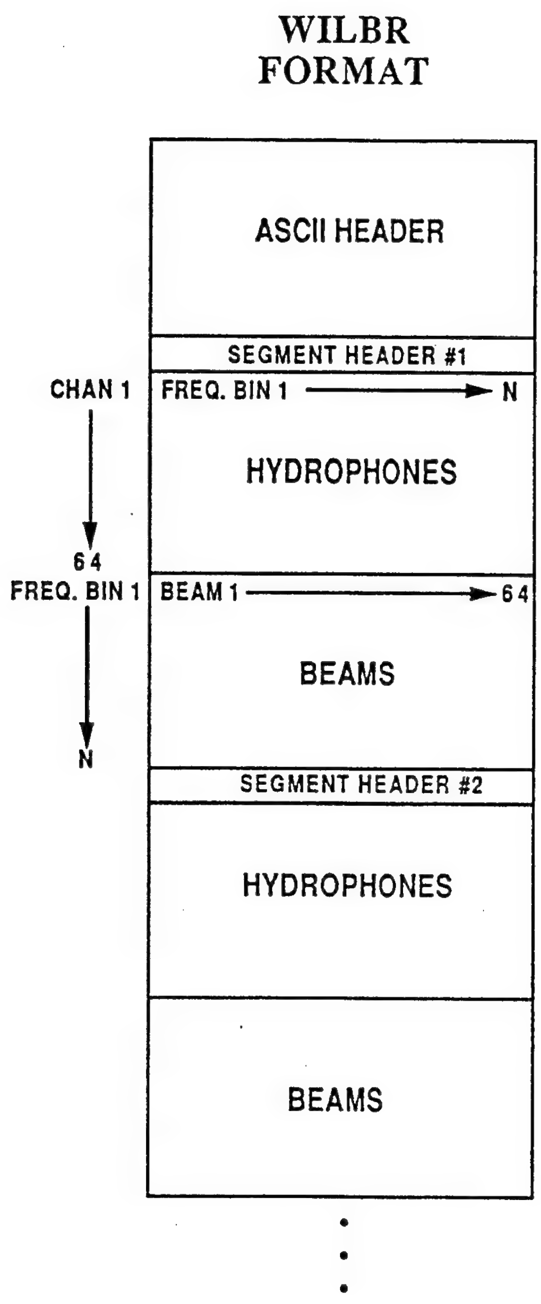


Fig. 14 – The WILBR file format

3.0 SECTION III: FOR THE DATA PROCESSOR, RUNNING WILBR

The optimal order of modules: Run NEWBEAM to create a WILBR input file. Run the Array Performance modules of WILBR: module 7 (VAX tape input) and module 3 (Stats). The optimal method is to process all legs with module 7 (VAX tape input). Then select module 3 (Stats) and repeat for each leg. Module 3 appends to several output files for use with the Ambient Noise modules as each leg is processed. After all legs have been processed with module 3, then run the Ambient Noise modules by selecting module 4 (Noise Calc), and the module 5 (Rose Plots). Both modules 4 and 5 can be repeated without reprocessing data with the Array Performance modules.

Because the WILBR output is only for 4 frequencies of interest, the modules must be rerun beginning with module 7 for other frequencies in the frequency range selected in NEWBEAM.

The programs are in order of use.

The following is a brief explanation of the questions and required responses in NEWBEAM and WILBR. Most questions are self explanatory, but are included for completeness. This manual is best used during a run of the WILBR software. The screen responses are given in bold with the explanations below.

The following is a list of information that will be needed to answer the input questions.

Calibrations for absolute values
- A/D (volts/bit)
- gains (dB)
- hydrophone sensitivity (dB)

Heading of leg (corrected for magnetic variation)
Sample rate (Hz)
Array spacing (m)
Number of hydrophones Sound speed (m/sec)
Number of phase reversed hydrophones
Position of phase reversed hydrophones (m) Array depth (m)
Location depth (m)
Date of measurements (for plots only)
Latitude and Longitude of measurements (optional)

3.1 Running NEWBEAM

The input tape MUST BE IN NORDIC 64 channel format or in LOGI format, The acoustic data will not be byte swapped.
This program processes data from DISC files such as DKB0:[dir.dir.dir]filename
The location and filename can total up to 40 characters.
You will be prompted for any output data that is not available from the data file.
As a consequence of this, several prompts occur after the header has been read.
****

dkb0:[dir.dir.dir]filename

Enter input file location and filename

The file location and filename can total up to 60 characters maximum.

Is the input file LOGI format? (y=1)
Enter a 1 for yes or a 0 for no. If yes, a PAR file must be in the same location as the data file. The program will search for filename.PAR. The following is displayed if yes is selected. If no is selected, then the program prompts for the output filename.
A LOGI formatted file will be reformatted to a NORDIC format by the NEWBEAM program.

Enter location and filename of reformatted file.
The file location and filename can total up to 60 characters maximum. The following is displayed when the reformatting is complete.

dkb0:[dir.dir.dir]filename.PAR 0
LOGI file has been reformatted to NORDIC format
Open of input file dkb0:[dir.dir.dir]filename.DAT was successful

dkb0:[dir.dir.dir]filename
Enter output location and filename
The location and filename can total up to 60 characters maximum.
This file will be the output file of the NEWBEAM program, i.e. the input file for WILBR.

The template filename's prefix is limited to 60 char. max.
Current template filename prefix is:
dkb0:[dir.dir.dir]watsun_beamer

Is this prefix OK? (Y/N) or (return)
Yes or return will proceed with the program. If no is selected, the following prompt appears.

Enter new filename prefix.
Enter only the prefix. ".DAT" is not necessary and will result in a program failure.

The template file that will be used is : dkb0:[dir.dir.dir]filename
WINDOW TYPE MENU
1= HP301
2= Hann
3= Hamming
4= Uniform
Select window #
Enter the number of the desired shading function.

Reading header block.
If the date/time group in the header of the PAR file has a 0 for the day, the value will be set to 1.

Enter the A/D volt conversion factor.
Enter the analog to digital conversion factor in volts/bit.

smp. rate	**A/D factor**
XXXX.XX	**X.XXXXXX**

The above is displayed after reading the header or PAR file. The sample rate is read from the header or PAR file and the A/D factor is an input value.

Enter array spacing type (0=equal, 1=unequal)

Enter the array heading
Enter the true heading, that is, the array heading should be corrected for magnetic variation. This value should be in integer form.

Enter the adjustable system gain, dB.
Enter a 0 here. WILBR will prompt for the calibrations.

Enter the LOW pass Filter frequency.
Enter any integer number here. The filter function has been included in WILBR.

Time in header at the beginning of this tape.
Year Day: Hour: Min: Sec:
0 1 0 0 0 0
Enter the start and end times to process. The tape will be searched and as much of the data found between the limits will be processed.
Format ==> day, hour, min, sec
Enter start time:

Enter stop time:
The stop time can be calculated from the number of points, FFT size, and sampling rate. The general rule is approximately 60 points.

Enter time domain FFT exponent to use, either:
13, 12, 11, 10, 9 or 8
The general rule is to select an FFT size to give a binwidth of approximately 1 Hz or less.

Enter type of a spatial FFT (0=FFT, 1=DFT)
If an unequal spaced array is to be processed, enter 1 for a DFT.
If an equal spaced array is to be processed, enter 0 for an FFT.
However, a DFT can be used to process an equal spaced array.

The next entries will determine which frequency ranges to beamform. You may enter up to five ranges in ***Ascending Order Fmax = XXX.**
Format: Low freq, Hi_freq (-1,-1 terminates list)
FFT Del_freq is X.XX
WILBR will only accept one frequency range of 256 bins or less.

Enter one freq. range (256 freq max)
Enter the lowest frequency of the range, the highest frequency of the range.

Enter one freq. range (256 freq max)
Enter -1,-1 to terminate the range.

The following is displayed for acceptance.
Freq. ranges selected: Lo Hi Actual Lo/Hi Bin Lo/Hi
Lo and Hi indicate the selected frequency range. Actual Lo/Hi displays the actual frequencies included based on the binwidth. Bin Lo/Hi is the number of bins in the selected frequency range.

Accept these values as entered, (Y/N) or (return)
If no, the program returns to prompt for the frequency range.

Equal Spaced Array (or **Unequal Spaced)**
Assuming digital array. Otherwise se
Select octave (3, 4, **5=enter spacing)**
The message of the array spacing is based on a previous entry. The applicable octaves of the digital array, DTAS, are for selection. The octaves are already programmed with the spacing for the DTAS. If the equally spaced array is not the DTAS, then enter the spacing in meters.

Current Channel Selections
Processing up to 256 channels is supported
Return to view the channel selection template
Chans:
Asgns:
Stats:
dB Adj:
Space:

The channel number (Chans) is displayed with the assignment (Asgns) channel number. That is, channel 1 is assigned to 1 when it is the forward channel. Channel 1 is assigned to the last channel number when channel 1 is furthermost from the ship. The status row indicates whether a channel is used/valid (1), unused/bad (0), or phase reversed (-1). The adjustment to the hydrophone sensitivity per channel is indicated in the dB Adj row. Finally, the location of each channel is row marked space. These values can be adjusted by exiting Newbeam and using the system editor.

Note: the spacing is calculated in the Newbeam and WILBR programs and is not read from the template file. Therefore any adjustments to the spacing via the editor will not be used in the program.

Template file OK? (Y/N) or (return)
Enter yes or no. If no, then a prompt for a new template filer name will appear with the option to exit the program.

No. of channels selected in template file = ##
Template file interpretation completed
Minimum beamformer FFT size is ##
as # channels selected was ##

Do you wish increase to next FFT size by zero filling?
Default is yes (Y/N) or (return)
Note that a <return> is the default "yes". In general, this question is answered by no.

Beam array will not be padded
This statement appears if the answer to the above question was no. If the answer was yes, then the statement reads: **Beam array will be zero padded.**

Enter---Reference S_speed at Ref_depth, m/sec.
Enter the sound speed at the depth of the array in m/sec. If vertical array data is processed, choose an average sound speed or a sound speed at depth of interest. This program does not have sound speed profile capability.

Processing begins.
Time in last record read is
year day: hour: min: sec:
total sees from beginning of file
Segment # was valid

Normal Program Exit
NEWBEAM is terminated and the system prompt is returned to the screen.

3.2 Running WILBR

Enter disk location (32 char max):
Disk location of the beamformer file to process. Can consist of several directories.

Enter printing device name or type RETURN for query each time.
To print to screen only, enter "MX11" in capitals. Other responses will make a UNIPICT file as well as print to the screen.

Rotate beams 1=Y, 0=No
This reorders the beams from the beamformed file. If NEWBEAM was used to beamform the data, then enter 1 if an FFT was used, enter 0 if a DFT was used.

Default values of various units are displayed. To change any of these, edit the file nfcfg.dat.

<RETURN>

Current projects on record are displayed. These are the selected project names from previous runs of WILBR. The project name gives the location and name of the WILBR processed data. A project name should be 8 characters or less. The project names can be deleted and/or added from this list, by editing the file "currproj.ref."

The main menu displays the various modules of WILBR.

1) Beamformer is not available. Use NEWBEAM, a stand alone beamformer, which offers an FFT or a DFT and the output is in WILBR format.
2) SACLANT tape input is inactive.
3) Statistics this module calculates and plots the array performance/data quality statistics, such as beam plot, phase plot, statistics table, TACDF, Rank Correlation Matrix.
4) Noise Calcs this module contains the Wagstaff Iterative Technique (WIT). It also calculates and plots the AACDF.
5) Rose Plots this module uses the results from the WIT algorithm to plot the horizontal directionalities, and calculate the Array Heading Rose. It also plots the beam noise in polar plots, as well as percentiles of the Horizontal Directionality.
6) SACLANT tape scan is inactive.
7) VAX tape input this module reads the output file of NEWBEAM, and calculates an FFT^{-1} to retrieve the hydrophones. Hydrophone plots are displayed here.
8) Reset Project this option allows another choice of an 8 character project name, then displays the above options again.

3.2.1 ARRAY PERFORMANCE AND DATA QUALITY MODULES

3.2.1.1 MODULE 7: VAX TAPE INPUT

Enter leg number to be processed (1 - 99)
Leg number 99 is reserved for a statistics leg (a tow along one heading for an extended period of time).

Enter Input filename:
Enter input filename only. Location is taken from the disk location.

Is this FWG towed array? (Y/N)
If no, the program assumes a hydrophone sensitivity of -151 and uses a SACLANT array filter function. If yes, the program sets a flag to call FWG towed array filter function and will inquire later for the hydrophone sensitivity.

When a file is successfully opened, the location and name are displayed. Otherwise, the input filename is asked for again.

Polygon number (for plots only) =
Enter an integer number between 1 and 99."For plots only" means that the entered number is not saved to the data file and only shows up on the plots.

Leg number (for plots only)
Enter an integer number between 1 and 99.

Standard frequencies (50, 147, 297, 595) 1=yes
Enter 0, to select different frequencies. Frequencies must be within the range selected in the beamformer routine NEWBEAM, otherwise errors will occur during the file read.

Enter 4 frequencies.
This command is displayed only if 0 was entered as a response to the previous prompt. Enter the desired frequencies in the format XX,XX,XX,XX. The values are real numbers.

Sampling frequency and temporal FFT length are read from the input file and displayed.

Enter hydrophone sensitivity.
This is usually a negative number. Enter it as a negative real number in the format -XXX.X.

Display of analysis frequencies that were selected and information from the input file.

> **Hydrophone to process (this is hardcoded to 31)**
> **No. of points to average**
> **No. of bad phones Time weighting**
> **Spatial weighting No. of acquired bands**
> **Band starting frequency (this is the first analysis freq)**
> **No. of samples per band is 256**

Enter SCU gain.
Enter an integer number or a real number with one decimal place. Program will truncate more decimal places.

Enter array heading.
This value is later used in the noise module to generate a Horizontal Directionality (HD). For accurate HD directions, use a true heading, that is, a heading that has been corrected for magnetic variance).

Enter Julian day:
This is used to annotated the plots.

Enter Year (XXXX):
Also used to annotate the plots.

Enter array/bottom depths (m)
Enter depths in meters. Used to annotate the plots.

Enter Latitude (degs,mins,sec):

Enter Longitude (degs,mins,sec):
Also used to annotate the plots. However zeros are usually entered.

Above selections are displayed.
Do you wish to use these values? Yes/No
Yes, continues the program. No, returns to "Enter Julian date".

Data processing begins at this point. "Ping nr." is the sample number of the data read from the input file. BEAM SHIFT NOT ACTIVE and BEAM SHIFT ACTIVE messages notify the user whether the beams were reordered (0 = not active, 1= active). See above.
The message, "HPFUNC error freq < 0", is not an error message, but a notification that all four analysis frequencies for the sample were processed.

Unit file 10 is the location and name of the resulting file from this module. It is later used in the STATS module. Actual number of hydrophones is set to 64. This is hardcoded. This version of WILBR only produces 64 beams, although most of the storage arrays are for 256.

Enter phone spacing:
Enter phone spacing in meters. This number is later used in the beam direction calculation of the HD. If an unequal spaced array is used, enter the smallest spacing.

Enter sound velocity:
Enter sound velocity in meters/sec. If processing data from a vertical array, then enter an average number or a sound speed of interest.

Opening unit 10: location.filenameS.LX
This S-file is used in later modules. It is an ASCII file containing sound speed, number of phones, number of beams, spatial weight, and time weight.

Plot title:
This is not used at all. Hit <return> to continue.

Plot Hydrophones (1=yes)?
Yes, will print the hydrophone plot to the screen, and if a printer was selected at the beginning of the program, will make a UNIPICT file for a later hardcopy. If No is selected, the hydrophone plot will not come to the screen and a UNIPICT file will NOT be made.

End of this module. The directory is once more displayed. From here, STATS (option 3) can be selected. However if option 7 is desired, exit the program and run again.

3.2.1.2 MODULE 3: STATISTICS

Enter leg number to be processed (1 - 99)
99 is reserved for a statistics tow. The input file to this module is generated from module 7, projectname.LX. The leg number entered here is used to locate the correct input file for processing.

Input the new leg number to be used in processing.
This leg number is usually the same as above. However, with this option the legs of the polygon do not have to be processed in consecutive order and/or legs can be omitted. Module 3 builds an

input file for the Noise module, which requires the legs to be consecutive. The number entered here must be the order of processing number, regardless of actual leg number.

Output file: projectnameN.res
This is an ASCII file of beam noise for each leg at each analysis frequency. It is an input file for module 4.

STATS Main Menu
1) Output to printer (not used)
2) Accumulate CDF data (ON/OFF) (not available, use 'off')
3) Output file (not used)
4) Noise file (NEW/APPEND)
(Select NEW for the first leg to process, then APPEND for the remaining legs.)
5) Statistics (NORMAL/NO NORMAL) (use normal only)
6) Scratch current plot file (NO/SCRATCH) (use 'scratch')
Enter option S)ave setup, P)rocess, or Q)uit:

The options for statements 1-6 are in parenthesis (). Those options with a slash / can be toggled by entering the statement number until the desired option appears.
Note: It is important to ensure that option 4 reads "append" when processing leg numbers 2 and higher.
S will save the menu setup for the next run. (Except for option 4, which must be checked each time a leg is processed.) P will begin processing. Q will return to the Main Menu.

Plot accumulated CDF function (Y/N):
Answer No. If yes is selected the program may crash due to the unavailability of this option.

Do you wish to see phase plots? (1=yes)
This will display phase plots to the screen. If yes is selected, the following question will be displayed.

Plotting hydrophone phase information.
At frequency XX Hz the maximum level is found at azimuth XX.XX deg
Please enter the new azimuth angle now
or -999, to use the above angle=>
For each analysis frequency, the program selects the maximum level from the beam plot and uses this direction as a default for the phase calculation.
If TACDF (Temporal Anisotropic Cumulative Distribution Function) was selected, the following appears.

Input beam number (3 max) 1 to 66
(Enter three integers (0 = no beam)):
Choose three beams to process for the TACDF. If only 1 or 2 beams are desired, use 0 to full the remaining input beam numbers. For example: 3, 20, 0. This will select only two beams, numbers 3 and 20.

Input analysis frequency (0 - 4, 0= all):
Select which frequencies to process for TACDF. 0 = all, 1 = first analysis frequency, 2 = second analysis frequency, etc.

Do you wish to see beam plots? (1=yes)
Prints plot to screen. If a printer was selected at the beginning of the program, then a print file is made. If no is selected, no plots to the screen and no print files will be made.

End of module. The resulting output file is in the form of an ASCII file called STATS.DAT and can be found in the executable directory. This file contains the beam noise statistics in tabular format and a rank correlation matrix for each analysis frequency.

3.2.2 *AMBIENT NOISE MODULES*

After all leg data has been processed with module 7 and module 3, then the ambient noise products can be calculated. All legs must be processed with module 3 to make a projnameN.res output file. This is an ASCII format file which contains the beam noise data for each leg for each of the four analysis frequencies. The legs must be numbered consecutively in this file, if not, the program will terminate with errors.

3.2.2.1 MODULE 4: NOISE CALC

Run WILBR and answer the first questions under the Running WILBR section until the main menu appears. Select module 4 (Noise Calc's). This module uses projnameN.res and projnameS.L# as input and calculates the horizontal directionality using Wagstaff's Iterative Technique (WIT). This module also calculates the Azimuthal Anisotropic Cumulative Distribution Function as well as displays it.

After selecting module 4 from the main menu, the input filename and three output filenames are displayed.

Calc's Main Menu
1) Input file -- dkb0:[dir.dir.dir]filenameN.res
2) Number of freq #
3) Number of legs #
4) Spatial shading (Hann/Uniform)
5) Sector relative to North (No/ G,H) **G - input center**
H - half width
6) Degrees for smoothing #
7) Bad phone (ignore/#)
8) Sector relative to array (No/ I,J) **I - input center**
J - half width
9) WIT in use (Median-dBavg)
A) AACDF probability plots (no/yes)
B) Listing output to (printer/tape/tape-print/none)
C) Noise calc's TILT or Vertical structure (none/ K-N)
K - (deg) TILT
L - (deg) vertical extent of noise
M - (deg) width of notch
N - (deg) depth of notch
Enter option S)ave setup, P)rocess, or Q)uit:

The options for statements 1-9 and A-M are in parenthesis ().
Those options with a slash / can be toggled by entering the statements number until the desired option appears. Otherwise, when a statement number is entered, a prompt appears.

Option 1 informs the user of the file to be used in processing with module 4.

Option 2 asks for the number of frequencies in filenameN.res.
This number is usually 4, that is the 4 analysis frequencies.
But the number could be less than 4, but in any case, the entered value must match the number of analysis frequencies in filenameN.res. If this number is not the same, an error will occur.

Option 3 asks for the number of legs in the filenameN.res file.
This is the number of legs processed with module 3. If the number entered is not the same as the number of legs in the file, an error will occur.
Note: The filenameN.res file is an ASCII file and can be modified with a system editor.

Option 4 use Hann.

Option 5 and 8 ask for the sector of valid beams for calculating the AACDF. Select either a secret relative to North (option 5) or a sector relative to the array (option 8). Select 'no' for other option. Enter the center angle of the sector (input center). Enter the half width of the sector. This is the width of the sector on either side of the center (half width). For example: The noise characteristics on beams forming a 60 deg sector centered at broadside for all legs of a polygon are desired. In this case, enter 5 until option 5 reads 'no'. Enter 8 until option 8 reads I and J. Enter I, then 90 for the center of the sector, which is broadside. Enter J, the half of the width of the desired sector, which is 30. Another example: If the noise characteristics in a 60 deg sector looking in the southwest direction of the polygon are desired, then select option 5 to read G and H and 'no' for option 8. Enter the center direction (G) of the sector desired, in the case 225. Enter the half width (J), 30 deg. For each leg of the polygon, the statistics are calculated using the beams in the defined sector.

Option 6 is usually set to 10 deg for smoothing in the WIT calculations.

Option 7. Use ignore.

Option 8, see option 5.

Option 9 selects the type of statistic to appear on the horizontal directionality pits. Median is the standard choice, because it is a robust statistic.

Option A. Select 'yes' to calculate the AACDF. If AACDFs are desired, either option 5 or 8 must be select as well.

Option B uses only 'printer.'

Option C is rarely used.

S will save the menu setup for the next run. P will begin processing. Tables of noise iterations will scroll on the screen during the processing. These are saved in a output file called FOR008.DAT, which is placed in the directory of the executable. Q will return to the Main Menu.

If the AACDF was selected, it will be displayed at the end of processing. When the Noise module is finished, the Main Menu is returned. At that time, module 5 (Rose Plots) can be selected.

3.2.2.2 MODULE 5: ROSE PLOTS

This module calculates the Array Heading Roses (AHR) for the analysis frequencies and displays the horizontal directionality, percentile directionality, polar beam noise plots, and Array Heading Roses. An Array Heading Surface (AHS) can also be calculated, and a file is generated. However this version of WILBR does not have a plotting routine for the AHS.

PLOT'S MAIN MENU

1) Output of ARRAY headings - Printer
2) Calculate ARRAY heading ROSE - Yes/No

		(Center)	(Width)
3)	**Section 1**	**45**	**30**
4)	**Section 2**	**135**	**30**
5)	**Section 3**	**225**	**30**
6)	**Section 4**	**315**	**30**

Enter option Slave setup, P)rocess, or Q)uit:
The above options are toggled by entering the desired option number. If more information is required, the program prompts the user with a question.

Option 1 uses only 'printer.'

Option 2. To calculate and print out Array Heading Roses select 'yes'. Otherwise toggle option 2 to select 'no'. If 'no' is selected, the horizontal directionality, percentile plots, and polar beam noise plots can still be printed.

Options 3 through 6. Enter the option number to change the center and width entries. The center and width describe the "look" sector for the AHR, the shaded section in Fig. XX. The AHR is calculated based on the sector. Four different "look" sectors can be chosen.

After entering P to process, the following questions appear.

Do you want hor. direc. plots (1==> yes)

Save noise rose data in a disk file? (1=>yes)
A yes response will save the data in an ASCII text file called FOR008.DAT. If option 2 of Plot Menu is not selected, then this file will not be made.
If horizontal directionalities were selected, the plots come to the screen.

Noise Field Plots completed
***** Calling ARSPL *****
Do you want array hdg. rose plots(1==>yes)

Do you wish to generate an array heading rose surface???(1=yes)
This will generate a file called HEADROSE.DAT, which contains 360 headings at each of 360 sector directions for the analysis frequency currently being processed. HEADROSE.DAT is an input file to a standalone plotting routine that is not available with this WILBR version. This question repeats at each analysis frequency.
If yes was selected the following statement appears:
Freq. = XX.XX Centre = XXX

Now processing angle XX at XX.XX Hz
This statement appears to notify the user of the sector angle and frequency of the array heading rose being processed. These values were selected in the Plot Menu.

Array Heading Rose Plots completed
Do you wish to see percentile plots(1==>yes)
If yes, the following question must be answered with yes.

Do you want hor. direc. plots (1==>yes)
Save noise rose data in a disk file (1==>yes)
Answer no here. This will only make a duplicate file of AHR data.

Do you wish to see beam plots (1==>yes)
A plot for each leg direction comes to the screen. To continue hit <return>.
After module 5 is finished, the Main Menu returns to the screen.
Select Quit to end WILBR and to return to the system prompt.

4.0 SECTION IV: MODIFYING WILBR ON THE ALPHA

This section contains hints and tips to modifying the WILBR software code. The commonly requested software modifications are for array spacing, filter functions, weighting functions, and, of course, format of input data. These are discussed below and include "pointers" to the software code requiring changes for the desired modification.

4.1 Array Spacing

If the array to be processed is equally spaced but has a different spacing than DTAS, no changes need to be made to the program. When running the WILBR beamformer, answer the array spacing questions with the options 'equal spaced' and 'octave 5'. The octave 5 option allows a different spacing to be used for an equally spaced array.

If the array to be processed is unequally spaced but has a different configuration than DTAS, changes to both the beamformer and WILBR processing must be made. Changes in the beamformer should be done in the subroutine SPACING.FOR. This is a separate subroutine for easier modifications. It can be replaced with a new subroutine with the appropriate spacing configuration or it can be modified. Corresponding changes must be made in WILBR as well. Make these changes in FWG_SPACING.FOR. This is a separate routine in the WILBR processing code and can be modified or replaced as SPACING.FOR.

4.2 Filter Function

If the data requires a different filter function, subroutine HPFUNC.FOR of the WILBR processing code must be modified. This is a separate subroutine that can be modified with a new option or replaced.

4.3 Weighting Function

The WILBR beamformer offers Hann, Hamming, and Blackman weighting functions, however WILBR offers only the Hann weighting function. To make modifications, changes should be made in the subroutine SHADE.FOR for the beamformer and WEIGT_PS.FOR and WEIGT_DFT.FOR in WILBR processing. WEIGT_PS and WEIGT_DFT are necessary to calculate the inverse weighting, so the hydrophones can be reconstructed from the beams. If the data will be using a DFT, the only current option available is Hann. Because the shading function depends on the spacing of the array and if the array is unequally spaced, the new shading function will have to be modified to accommodate unequal spacing.

4.4 Format of Input Data

See section II for detailed descriptions of available formats. If the data file differs from these the following are suggested modifications. The beamformer was originally written for NORDIC formatted data and incorporates the file reading routines in several subroutines. The method with the least amount of impact to the main beamformer routine, NEWBEAM, is to reformat the input data into NORDIC format. In this case a read routine similar to the LOGI.FOR subroutine would be written and called instead of LOGI or as an option.

Should it be desired that the beamformer process the new format as a standard, several routines must be modified. These subroutines are found in the main routine NEWBEAM.FOR and are listed below.

GET_OPTIONS. Open file statements for both the NORDIC format and the LOGI format are in this subroutine.

READ_HEADER. This reads the 16384 byte header block and prompts for additional information. The header information is read into a character buffer, then the values from the buffer are read into the appropriate variable names.

GETRECRD. This reads in a buffer of character data and checks for EOF. The character buffer is equivalenced to an integer*2 buffer.

GETNEXTSEG. This reads the buffer file, which was read in by GETRECRD. If the data is not VAX-type data, that is, it is not compatible with the VAX system, then a byte swap is needed. This can happen with data from other laboratories. A do-loop for byte swapping is included in GETNEXTSEG. Simply remove the comments.

The major read loop occurs in the main routine NEWBEAM.FOR. The subroutines are called in the order: GET_OPTIONS, READ_HEADER, GETRECRD, GETNEXTSEG, GETRECRD. The resulting output file is written in the main routine as well.

Note: The template file determines the positional assignments of the channels as selected. The A/D factor is applied in GETNEXTSEG.

4.5 Re-validating WILBR after Modifications

After any modifications, NEWBEAM and WILBR should be re-validated to have confidence in the results. Often a modification affects another part of the routine, therefore validations must be made before using the system to process data. There are two suggested methods.

One method is to maintain a data file and corresponding WILBR plots for the data file. When a modification is made, the data file with the same parameters should be run through the programs and the results compared to the WILBR plots. This is a good check if modifications were made to speed processing operations, after downloading to a new system environment, making updates on plots, etc.

Another method is to process data from one channel. This can be done with WILBR by modifying the template file with the system editor. Select a channel known to be a valid hydrophone. For each channel of the array, assign the selected channel in the second row of the template file. This gives an array with the same data on all channels. Process with NEWBEAM followed by WILBR. Figures 15, 16, and 17 are example WILBR plots from such a test. The hydrophone plot, Fig. 15, should be a straight line for the median, percentiles and the PRDIFF envelope. The beam noise plot, Fig. 16, should show a peak at broadside (beam #32) and the PRDIFF envelope should also indicate a high level at broadside. Finally, the phase plot will be a straight line when the broadside beam, 90 deg, is entered at the azimuth angle (see section 3.2.1) in WILBR. This is a good method to validate the FFT, new shading functions, filter functions, etc.

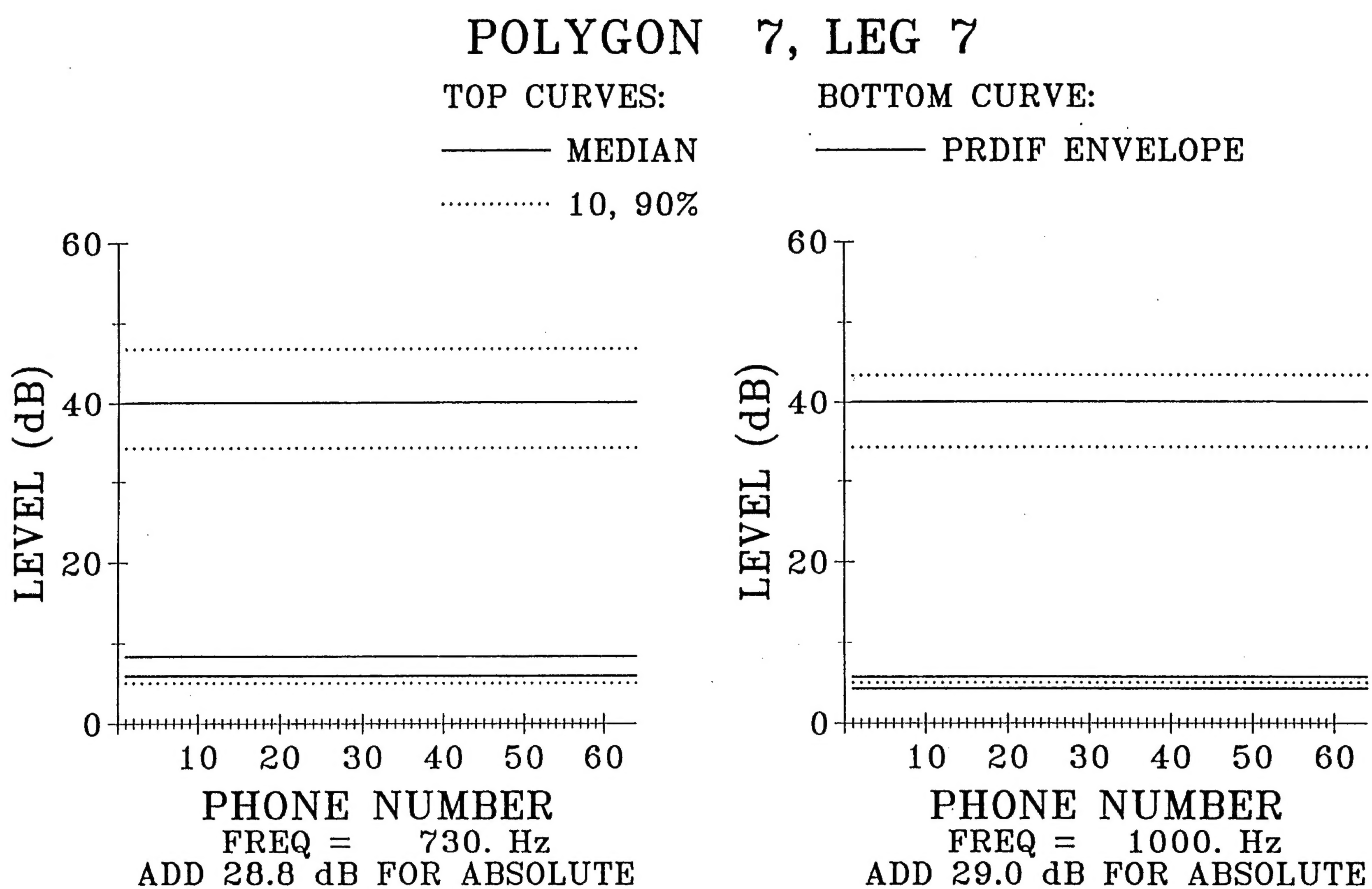


Fig. 15 – Hydrophone plots showing the same data on all channels

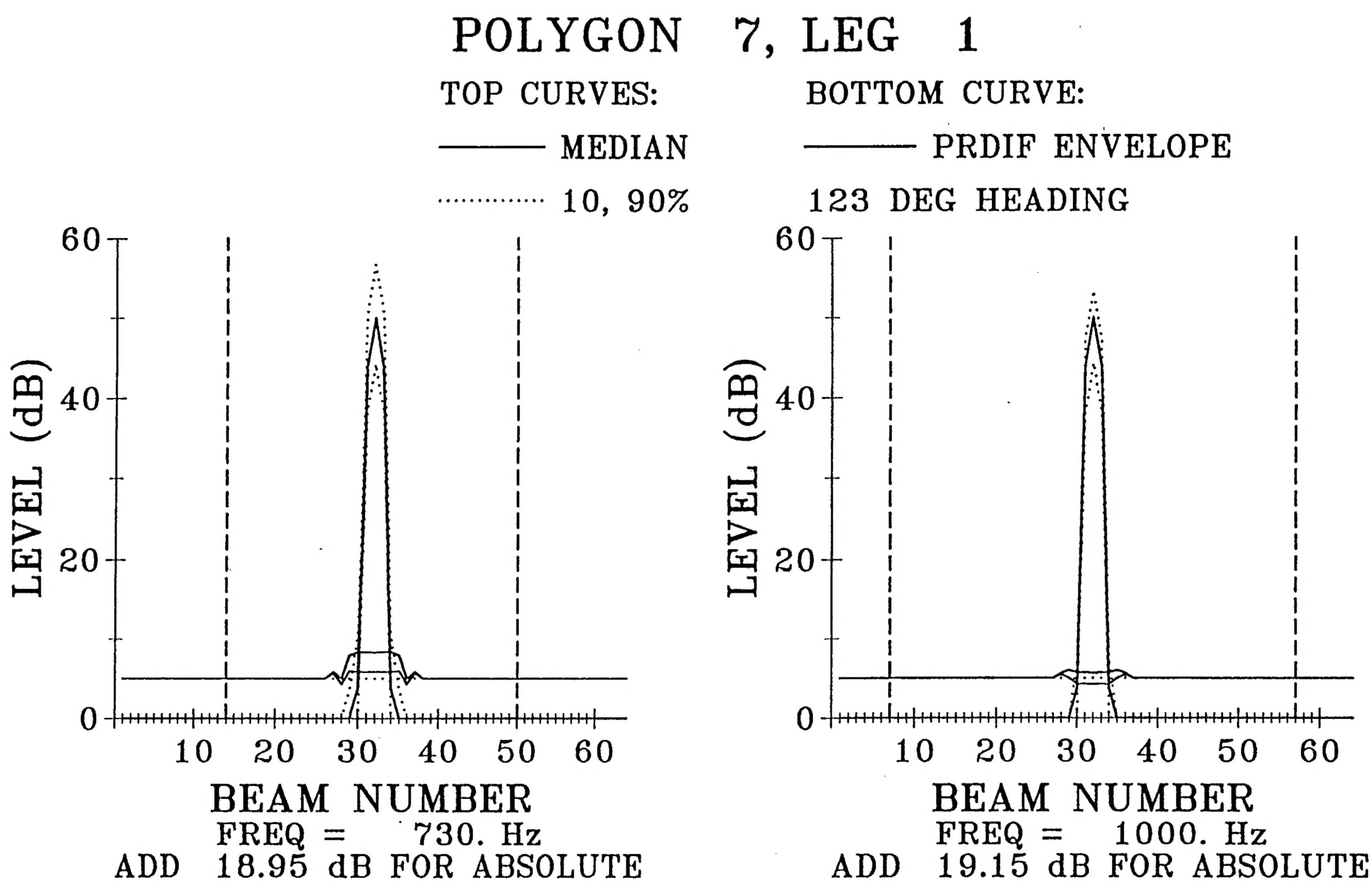


Fig. 16 – Beam noise plots resulting from the same data input on all channels

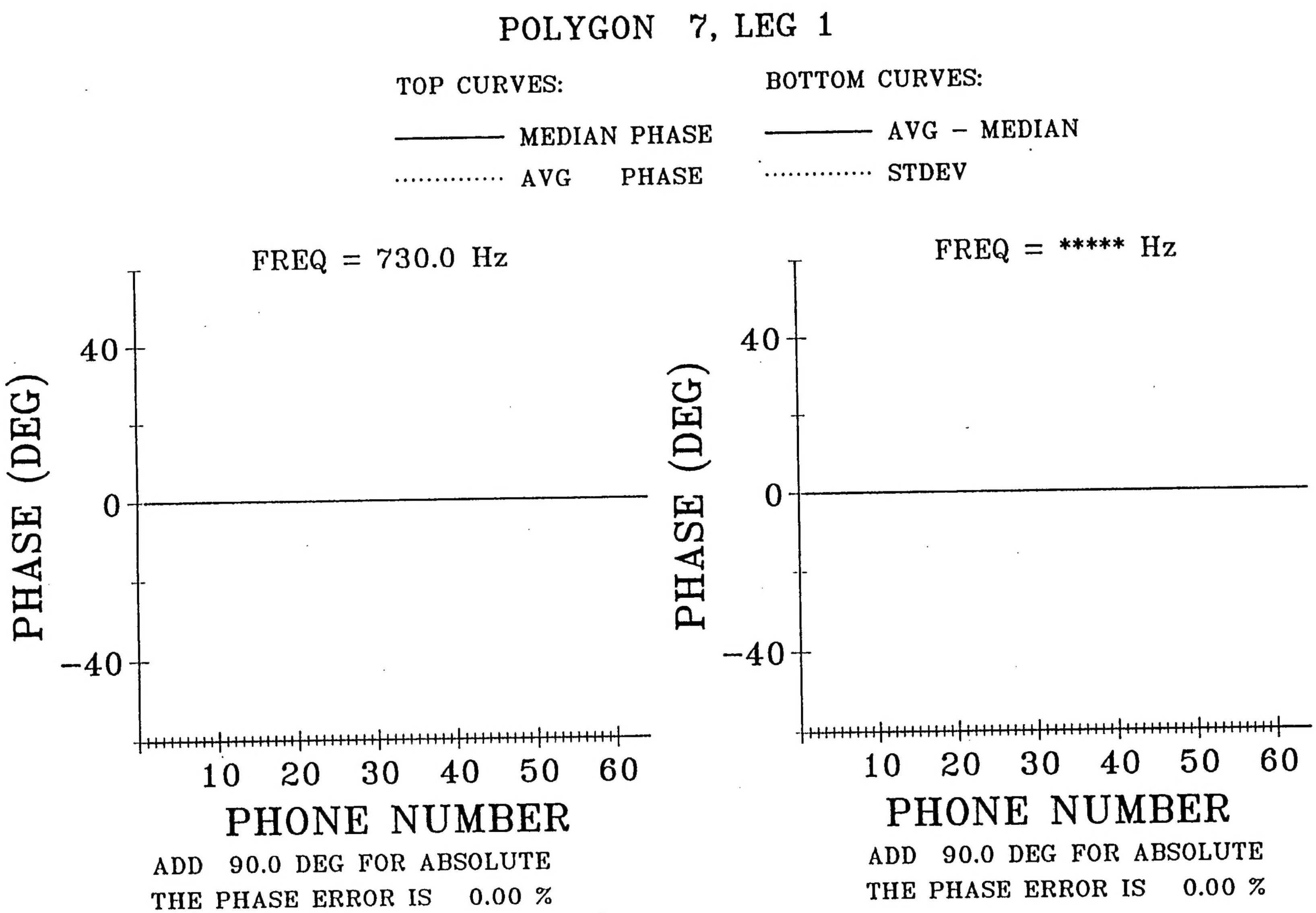


Fig. 17 – Phase plots resulting from same data input on all channels

5.0 REFERENCE LIST

1. Wagstaff, R. A. (1978). "Iterative Technique for Ambient Noise Horizontal Directionality Estimation from Towed Line Array Data," JASA, 63, No. 3, pp. 863-869, Mar.

2. Wagstaff, R. A. (1993). "A Computerized System for Assessing Towed Array Sonar Functionality and Detecting Faults," IEEE J.Oceanic Engr., Vol. 18, Oct.